US Army Corps
of Engineers®
Portland District

# WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

# DRAFT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

**November 25, 2022**

# DRAFT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR WILLAMETTE VALLEY SYSTEM O&M

## November 25, 2022

**Lead Agency**

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

**Cooperating Agencies**

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

**Proposed Action**

The Proposed Action is continued operation and maintenance of the Willamette Valley System in compliance with the ESA and all other applicable laws and regulations. The Preferred Alternative is Alternative 5.

**Affected Areas**

State: Oregon
Counties: Benton, Lane, Linn, Marion Counties

**Contact for Further Information:**

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**Public Comment Deadline:** January 19, 2023

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

There are no permit, license, or entitlement requirements related to the proposed action under review. This is a programmatic proposal review. Any permit, license, or entitlement requirement will be identified in subsequent, tiered environmental reviews as applicable.

## Abstract

The U.S. Army Corps of Engineers, Portland, Oregon District, has prepared this draft Willamette Valley System Operations and Maintenance Programmatic Environmental Impact Statement (PEIS) in accordance with the National Environmental Policy Act (NEPA). Several cooperating agencies and tribes participated in development of this PEIS by providing information and review throughout the draft PEIS process. Public involvement during the scoping process also helped to inform the draft PEIS content and development process. Scoping for the PEIS formally began on April 1, 2019, with publication of a Notice of Intent in the *Federal Register.*

To meet the many purposes of the Willamette Valley System, the U.S. Army Corps of Engineers manages a complex operation that includes storing and releasing water from the 13 system reservoirs to balance various needs and demands throughout the year such as flood control, fish and wildlife, hydropower, recreation, irrigation, water supply, water quality, and navigation.

The Proposed Action reviewed in this PEIS is continued operation and maintenance of the Willamette Valley System for specific, authorized purposes and in compliance with the Endangered Species Act (ESA) and all other applicable treaties, laws, and regulations. This PEIS review is at the program level rather than the site-specific project level (site-specific NEPA analyses would occur when projects are proposed as discussed in the PEIS).

The last PEIS that evaluated the Willamette Valley System operations was completed in 1980. Over the ensuing four decades following completion of the 1980 PEIS (1980 – 2022), operations have been modified and structural measures for fish passage and temperature control have been implemented to improve conditions for ESA-listed fish species. Information relevant to the environmental effects of operating the system has also been acquired since the 1980 PEIS was finalized, including information related to ESA-listed fish species.

The PEIS describes and evaluates impacts related to a No Action Alternative and seven action alternatives that address the Proposed Action. The alternatives are suites of measures for Willamette Valley System management options that vary among the alternatives. Measures are characterized into general categories, including flow, water quality, downstream fish passage, upstream fish passage, and measures common to all action alternatives such as gravel augmentation and operation and maintenance of adult fish facilities among others. Anticipated impacts were analyzed for all environmental and social resources potentially affected under each alternative.

The U.S. Army Corps of Engineers also identifies a Preferred Alternative in this draft PEIS.

# EXECUTIVE SUMMARY

## 1 PREFACE

The Willamette River Basin (WRB) is located entirely within the state of Oregon, beginning south of Cottage Grove, and extending approximately 187 miles to the north where the Willamette River flows into the Columbia River. The basin is more than 11,200 square miles, averages 75 miles in width, and encompasses approximately 12 percent of the total area of the state (Figure ES-2). The Willamette is the 13th largest river in the conterminous United States (U.S.) in terms of streamflow, producing more runoff per unit area than any of the 12 larger rivers. Within the watershed are most of the state's population, larger cities, and major industries. The basin also contains some of Oregon's most productive agricultural lands and supports nationally and regionally important fish and wildlife species. Thirteen of Oregon's thirty-six counties intersect or lie within the boundary of the Willamette River basin. The Willamette flows past Portland, Salem, and Eugene, the three largest cities in Oregon, en route to its confluence with the Columbia River. Many of the Willamette's own tributaries – such as the North and South Santiam, McKenzie (**Figure ES-1**), Middle Fork Willamette, Coast Fork Willamette, and Long Tom – are substantial rivers in their own rights.

**Figure ES- 1. The McKenzie River – a Willamette tributary – drains the heavily forested west slopes of the Cascade Range**

The Willamette River and its tributaries have long influenced the lives of the WRB's residents: human, fish, and wildlife alike. Since time immemorial, indigenous peoples have depended on these rivers for many resources including, but not limited to, fishing, trade, transportation, and water supply. Fish within these rivers including salmon, lamprey, sturgeon, and bull trout are also an essential component of tribal identity and culture.


**Figure ES- 2. The Willamette River Basin depicting USACE projects**

As American settlers of European descent began to appear in the WRB in the mid-1800s, the Willamette River and its tributaries became important resource for them as well. They too relied upon these rivers for transportation, trade, fish harvest, and irrigation water.

The first Euro-Americans on the Willamette encountered a broad valley with a shallow braided channel across a wide floodplain that flooded annually during winter months. As these settlers established agriculture and settlements in the Willamette Valley, the frequent flooding, including the devastating 1861 event that inundated Portland's business district for weeks, eventually led the United States (U.S.) Congress to authorize the U.S. Army Corps of Engineers (USACE) to construct, operate, and maintain a system of dams and reservoirs – the Willamette Valley System (WVS) – for flood control purposes.

Subsequently, USACE constructed 13 dams and extensive bank protection revetments along the Willamette River and its tributaries, creating the WVS by the 1970s. The WVS was originally authorized by the Flood Control Act (FCA) of 1938, including authorization for the following dam construction projects: Fern Ridge on the Long Tom River (**Figure ES-3**), Dorena and Cottage Grove in the Coast Fork Willamette sub-basin, Lookout Point on the Middle Fork Willamette River, and Detroit on the North Santiam River. Subsequent FCAs authorized Big Cliff on the North Santiam River, Green Peter on the Middle Santiam River, Foster on the South Santiam, Cougar and Blue River dams on the McKenzie River, Hills Creek and Dexter on the Middle Fork Willamette River, and Fall Creek on Fall Creek.

**Figure ES- 3. Fern Ridge was the first of 13 dams to be built in the WVS**

However, flood control – or what is commonly referred to as flood risk management (FRM) – is just one many functions of the WVS (**Figure ES-4**). Each project (dam and reservoir) has up to eight purposes authorized by Congress. These include flood control, irrigation, navigation, hydropower, fish and wildlife, water quality, recreation, and municipal and industrial water supply. The WVS dams provide approximately $1 billion in annual flood risk benefits, 26 million in hydropower revenue, and 5.4 million in recreation benefits.


**Figure ES- 4. The WVS serves multiple functions**

Many local communities and economies have developed largely from the availability of the resources provided by these authorities which have profound societal benefits to the state of Oregon.

However, these societal benefits have come at an environmental and social cost. A substantial environmental cost was imposed on native fish and on the people who depend on them – particularly Native American Tribes. The initial construction of 13 dams and reservoirs blocked the upstream and downstream migration and flooded spawning and rearing habitat of multiple salmonid species and Pacific lamprey.

In addition, while the WRB comprises just 12 percent of Oregon's land area, it contains about 70 percent of the state's population. The effects to fish from increased population growth and associated development add to the ongoing effects of operations and maintenance of the WVS. Collectively, these effects on Willamette natural-origin fish populations have contributed to their sharp population declines. Activities that have further affected fish include urbanization, development in wetlands, riparian areas, and floodplains, overfishing, water diversions, release of sanitary and industrial pollution, introduction and increase of invasive species, mining, farming, ranching, and logging. Hatchery-produced fish have also become the dominant populations in the WRB and continue to compete for resources with natural-origin fish. Furthermore, global factors outside of the WRB, such as climate change and changing ocean conditions, have had additional adverse effects to salmonids and Pacific lamprey.

Concern over ongoing, long-term population declines led to the listing of Upper Willamette River (UWR) Chinook salmon (**Figures ES-5 and ES-6**) and UWR steelhead (**Figure ES-7**), and bull trout (**Figure ES-8)** as federally threatened species under the Endangered Species Act (ESA). The National Marine Fisheries Service (NMFS) listed UWR Chinook salmon and UWR steelhead trout in 1999 and designated critical habitat in the WRB for UWR Chinook salmon and UWR steelhead in 2005. The U.S. Fish and Wildlife Service (USFWS) listed bull trout as threatened within the coterminous U.S. in 1999 and designated critical habitat in the Upper Willamette River Critical Habitat Unit (CHU) in 2010. Oregon chub were listed as endangered in 1993 and have been delisted in 2015 due to population recovery.

**Figure ES-5. "Silvery" adult Chinook salmon – recently returned from the sea**

**Figure ES-6. Adult Chinook salmon in reddish spawning colors**

**Figure ES-7 Male and female steelhead trout. Credit: NOAA Fisheries**

**Figure ES-8 Bull trout swimming upstream. Photo by: Joel Sartore/National Geographic & Wade Fredenberg/USFWS**

Subsequently, in 2008, NMFS issued a Biological Opinion (BiOp) that evaluated the effects of continued operation and maintenance (O&M) of the WVS to UWR spring Chinook salmon and winter steelhead trout. NMFS concluded that continued O&M as proposed by USACE during the ESA Section 7 consultation process was insufficient to avoid jeopardizing the continued existence of these two species in the WRB, or adverse modification of their designated critical habitat. The 2008 NMFS BiOp provided a Reasonable and Prudent Alternative (RPA), composed of a suite of actions that if implemented would be expected to not jeopardize the continued existence of UWR Chinook salmon and UWR steelhead. In 2008, USFWS also issued a BiOp outlining the effects of the WVP on Oregon chub (now delisted), bull trout, and bull trout critical habitat.  The USFWS BiOp reached a no jeopardy determination as long as the Action agencies implement the NMFS BiOp RPA and consider the effects on Oregon chub and bull trout when applying measures proscribed in the RPA.

In the decades since the WVS projects were first constructed and began operation, and especially since the 2008 BiOp, USACE and its federal, tribal, and state partners have made considerable efforts of varying effectiveness to mitigate the adverse effects of the WVS – dams and reservoirs as well as miles of river revetments (**Figure ES-9**) – on UWR spring Chinook salmon, UWR steelhead, Bull Trout and other sensitive species, such as Pacific lamprey and Oregon chub. These have included: upstream passage past the dam such as adult fish collection facilities and fish ladders (**Figure ES-10 and ES-11**); downstream fish passage operations and structures; operations and structures to improve temperature; and hatcheries for fish rearing.

**Figure ES-9. Riprap (a type of revetment) on the bank of the Willamette Mainstem near Corvallis**

**Figure ES-10. Ladder at the Minto Adult Fish Collection Facility downstream of Big Cliff Dam on the North Santiam River**

**Figure ES-11. Rearing ponds at Marion Forks Fish Hatchery in the North Santiam Sub-basin**

## 2 INTRODUCTION

USACE has developed this Draft Programmatic Environmental Impact Statement (PEIS) for the continued O&M of the WVS, in accordance with the National Environmental Policy Act (NEPA). USACE prepared this PEIS in response to the need to review and update operations and maintenance of the 13 multipurpose projects (dams and reservoirs) and numerous revetments along the Willamette River and tributaries, in accordance with authorized project purposes, while still meeting obligations under the ESA to avoid jeopardizing the continued existence of ESA-listed species. The locations of these projects are shown in **Figure ES-12**.

To meet the many purposes of the WVS, USACE manages a complex operation that includes storing and releasing water from the 13 WVS reservoirs to balance various needs and demands throughout the year such as flood control, fish migration and habitat, hydropower power peaking, recreation, irrigation, water quality, and water supply. Intermittently, an action taken to meet one need makes it more challenging to meet one or more other needs. For example, in the fall, operators begin drafting WVS reservoirs (lowering water levels) to provide for flood risk management during the high-precipitation winter months. However, come early spring, there must be enough water available to help propel juvenile salmon (smolts) in their journey downstream toward the Pacific Ocean.

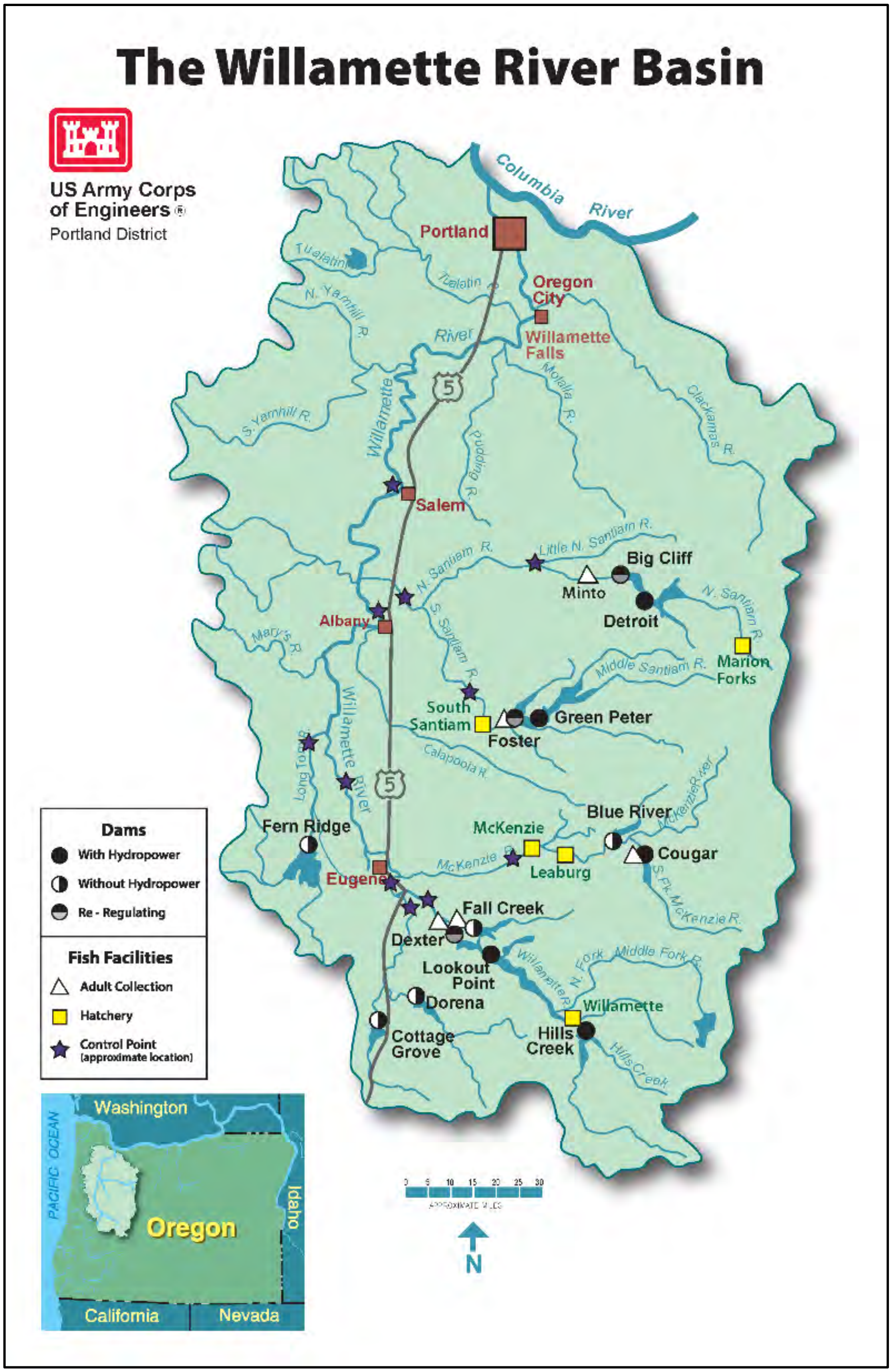


**Figure ES- 12. The WRB, showing locations of WVS projects, including dams and reservoirs, adult fish collection facilities, and fish hatcheries**

In addition, other federal agencies use the WVS include the Bonneville Power Administration (BPA), which is authorized to market and transmit the electrical power generated by the eight hydropower plants in the WVS, and the Bureau of Reclamation (BOR), which conducts water marketing to water users within the WRB. As a result, because all WVS purposes and users are important, actions that affect those purposes and users must be carefully planned, coordinated, and implemented.

As part of the WVS PEIS, USACE analyzed the environmental, economic, and social impacts of the no-action and seven action alternatives, reviewing new scientific and technical information, where applicable.

This Executive Summary provides an overview of the draft PEIS, which is a much larger document that contains highly detailed information, technical analyses, and results. The Executive Summary also furnishes an overview of the major environmental effects of the Preferred Alternative, but it is not intended to substitute for the more comprehensive draft WVS PEIS document. The draft WVS PEIS provides a detailed description of the environmental effects of not only the Preferred Alternative, but also the No Action Alternative and the other six action alternatives. Table ES-1 below identifies the major topics and chapters of the Draft PEIS. Where possible, the executive summary points to the Draft PEIS chapter and section at which the reader can find further details on a given topic.

**Table ES-1 Chapters of the draft WVS PEIS with summary of content**

| Chapter Number | Chapter Title | Chapter Content |
|---|---|---|
| **1** | Introduction | Provides background information on the NEPA, ESA, and WVS |
| **2** | Alternatives | Provides an overview of the alternatives' development process. Describes the suites of measures that comprise 7 action alternatives that meet the purpose and need of the PEIS. Describes the No Action Alternative and the 7 Action Alternatives. |
| **3** | Affected Environment and Environmental Consequences | Analyzes the direct and indirect effects of the 8 alternatives across 24 resource topic areas. |
| **4** | Cumulative Effects | Analyzes the effects of the 8 alternatives in conjunction with the trends of past, present, and reasonably foreseeable actions and their effects on each of the 24 resource topic areas. |
| **5** | Preferred Alternative | Discusses the evaluation and comparison of the 8 alternatives and the selection of the preferred alternative as well as provides an overview of the preferred alternative and the implementation and adaptive management plans. |

| Chapter Number | Chapter Title | Chapter Content |
|---|---|---|
| **6** | Public Involvement | Describes the public involvement process for the WVS PEIS. |
| **7** | Compliance with Environmental Laws, Regulations, and Executive Orders | Provides the status of environmental and cultural resources compliance and explains the plan to update compliance. |
| **8** | Glossary | Provides definitions for terms used throughout the WVS PEIS |
| **9** | List of Preparers | Lists the authors, editors, and reviewers of the WVS by discipline and chapter |
| **10** | References Cited | Lists the references cited throughout the WVS PEIS. |
| **11** | Index | Indexed Terms |
| **12** | List of Appendices | Lists the documents prepared to inform and support the WVS PEIS. |

The geographic scope of the Draft PEIS encompasses the 13 USACE projects (dam and reservoirs) on the Willamette River and the sub-basins of the following tributaries: the North Santiam, South Santiam, McKenzie, Middle Fork Willamette, Coast Fork Willamette, and Long Tom. Also included in the geographic scope are revetments along the banks of the mainstem Willamette and its tributaries, fish hatcheries, and adult fish collection facilities. The temporal scope of this analysis is assumed to be 30 years from the signing of the Record of Decision (ROD), except for the socioeconomic-related resource analysis. A 30-year horizon for the EIS was determined appropriate due to the dynamic nature of the system and the current and future needs of the communities that rely on the system.

# 3 REGIONAL INPUT

USACE carries the responsibility and legal authority for managing the WVS in coordination with its tribal, federal, and state partners, and for collaborating with these partners and other cooperating agencies under NEPA to develop this draft PEIS. When initiating and preparing the draft PEIS, USACE understood the importance of seeking broad input from a diverse array of stakeholders in the region. USACE gathered input through public and agency scoping, cooperating agencies, and tribal consultation.

## 3.1 Public Scoping

Scoping for the PEIS formally began on April 1, 2019, with the publication of a Notice of Intent (NOI) in the *Federal Register* (Vol. 84, No. 62, pp. 12,237 – 12,238). Comments were accepted until June 28, 2019. The NOI also notified the public of the scoping meetings held at various locations within the Willamette Valley from June 4 to 13, 2019. Meeting participants included private citizens, utility boards/councils; watershed councils; farm associations; non-governmental organizations (NGOs); city, state, and federal representatives; and elected officials. A total of 384 comments were received from private citizens, NGOs, governments, government agencies, and tribes. **Table ES-1** shows the number of comments received by topic. The comments were used to inform the scope of analysis, alternatives development, and effects to resources in the draft PEIS

**Table ES- 2. Public Scoping Comments Received by Topic**

| Topic | # of Comments Received |
|---|---|
| Alternatives | 183 |
| Authority | 10 |
| PEIS general | 86 |
| Environmental effects | 90 |
| Mitigation | 5 |
| Not a comment about the PEIS | 10 |
| **Total** | **384** |

The Willamette Valley System Operation and Maintenance Environmental Impact Statement Public Scoping Report includes more details on the scoping process and comments, a database of comments received, and all scoping materials (see Appendix P). Chapter 6 of the WVS PEIS summarizes additional public involvement conducted by USACE for the WVS PEIS.

## 3.2 Cooperating Agencies

As the lead agency for this draft PEIS, USACE invited agencies with jurisdiction by law or special expertise relevant to the WVS and its O&M to be cooperating agencies. Agencies that accepted cooperating agency status are listed in **Table ES-2** below, and are described briefly in Section 1.6 of the PEIS and in detail in Appendix L. These cooperating agencies contributed to the draft PEIS by providing information and input throughout the NEPA process.

**Table ES- 3. Cooperating Agencies**

| Agency |
|---|
| **Tribal** |
| Confederated Tribes of Grand Ronde Community of Oregon |
| Confederated Tribes of Warm Springs |
| Confederated Tribes of Siletz Indians |
| **Federal** |
| Bonneville Power Administration |
| U.S. Bureau of Reclamation |
| National Marine Fisheries Service |
| U.S. Fish and Wildlife Service |
| United States Environmental Protection Agency |

| **Agency** |
|---|
| **State of Oregon** |
| Oregon Department of Agriculture |
| Oregon Department of Environmental Quality |
| Oregon Department of Fish and Wildlife |
| Oregon Water Resources Department |

In addition to being cooperating agencies, BPA and BOR are action agencies for the ongoing, reinitiated ESA Section 7 Consultation with NMFS and USFWS for the ongoing O&M of the WVS. These four federal agencies have met routinely with USACE to improve understanding and provide real time feedback on the PEIS and the Preferred Alternative to inform the proposed action. This coordination has occurred at various levels including the technical team level as well as the local and regional leadership levels. Topics from these meetings were also then shared with greater cooperating agency group in monthly meetings, as appropriate and relevant.

## 3.3 Tribal Consultation

USACE is committed to a Government-to-Government relationship with the tribal governments to address issues concerning tribal self-government, trust resources, treaties, and other rights. As a result, USACE has coordinated and collaborated with the tribes during tribal consultation, Section 106 consultation, and cooperating agency process (when a tribe has accepted the role as a cooperator) to gain their perspective on the planning and management activities of water resources, fish and wildlife resources, and other natural resources.

USACE initiated tribal consultation for the NEPA process in 2018. **Table ES-3** is a list of tribes with which USACE has initiated tribal consultation on the WVS PEIS. Tribal consultation is ongoing throughout the WVS EIS process.

**Table ES- 4. Consultation with Federally Recognized Tribes and Tribal Entities for the WVS PEIS**

| **Tribe or Tribal Entity** |
|---|
| Confederated Tribes of Grand Ronde Community of Oregon |
| Confederated Tribes of Warm Springs |
| Confederated Tribes of Siletz Indians |
| Confederated Tribes of Coos |
| Lower Umpqua and Siuslaw Indians |
| Cow Creek Band of Umpqua Indians |
| Columbia River Inter-Tribal Fish Commission |
| Coquille Indian Tribe |
| Klamath Tribes |

| Tribe or Tribal Entity |
| --- |
| Nez Perce Tribe |
| Confederated Tribes of the Umatilla Indian Reservation |
| Yakama Nation of Indians |

## 3.4 Key Issues and Resource Concerns

The NEPA public scoping process for the WVS PEIS resulted in the identification of issues important to stakeholders. The list below summarizes several of the key issues and resource concerns associated with the proposed alternatives.

- ESA comments conveyed concerns on ESA-listed species (particularly to UWR Chinook salmon, UWR steelhead, and bull trout), and effects of dams to anadromous fish migration patterns, water conditions affecting fish passage and fish populations, and general ecosystem effects
- Flood Risk Management comments conveyed concerns on the WVS flood risk, preserving human and economic resources, and balancing needs for flood risk management and fish and wildlife values
- NEPA Process comments conveyed concerns on how the PEIS may affect other ongoing USACE NEPA analyses within the WVS, cumulative effects to natural resources and ecosystems within the WVS, inclusion of information in the PEIS to inform analysis on fish habitats, water allocation and storage, and streamflow.
- Water Storage and Allocation comments conveyed concerns on water storage capacity and allocation, effects on irrigation and municipal water users, and effects from changing water storage on fish and habitat.
- Water Quality comments received conveyed concerns on water contaminants, water temperature, total dissolved gas, and drinking water safety
- Recreation comments conveyed concerns on recreational opportunities, effects to recreation of algal blooms and reservoir levels, recreation employment, recreation opportunities, and recreational effects to ESA-listed species

# 4 DEVELOPMENT AND COMPARISON OF ALTERNATIVES

After scoping and consideration of public input, an interdisciplinary team of USACE experts participated in alternatives development using information and feedback from multiple federal, tribal, and state stakeholders. The team used an iterative process to identify, screen, evaluate, compare, and refine alternatives. The alternatives development process utilized the purpose and need and well as UACE identified constraints and objectives for the Proposed Action as the basis of each alternative and associated suite of measures.

This meaningful engagement with federal, tribal, and state cooperators and the public through scoping has greatly enhanced the development of alternatives and the analysis in the PEIS. Sections 2.1 and 2.2 in the PEIS describe the alternatives development process in detail. **Figure ES-17** is a diagram depicting the iterative and sequential approach used by USACE in formulating alternatives, including a Preferred Alternative.

## 4.1 Purpose and Need

The purpose and need for the proposed action are the continued O&M of the WVS in accordance with authorized project purposes, while meeting ESA obligations to avoid jeopardizing the continued existence of ESA-listed species.

The proposed action is continued operation and maintenance of the WVS for specific, authorized purposes and in compliance with the ESA and all other applicable treaties, laws, and regulations. The last PEIS that evaluated WVS systems and operations was completed in 1980. Over the ensuing four decades following completion of the 1980 PEIS (1980 – 2022), operations have been modified and structural measures for fish passage and temperature control have been implemented to improve conditions for ESA-listed fish species. New information relevant to the environmental effects of operating the WVS has also been acquired, including information related to ESA-listed fish species.

More specifically, the aim of the proposed action and alternatives is to improve salmonid passage over dams and through reservoirs to increase their survival though cost-effective means while still meeting the Congressionally authorized project purposes of the WVS. Fish passage is a limiting factor affecting the prospects of recovery for ESA-listed and other native migratory fish. Improvements to salmonid passage includes both the passage of adults migrating upstream to spawn, and juveniles (smolts) migrating downstream toward the ocean.

## 4.2 Constraints

Constraints based on the purpose of and need for the proposed action and life safety were identified. Potential alternative measures were eliminated from consideration for the following reasons:

- Flood Risk Management: Results of the preliminary modeling were used to screen any measures with potential adverse flood risk effects. Specifically, measures that would result in flood risk management changes from current protection levels were eliminated as an alternative measure.
- Dam Safety: USACE performed a preliminary evaluation of measures for dam safety considerations. Measures that would compromise dam safety and that could not be mitigated were eliminated as an alternative measure. A more detailed dam safety evaluation of components will be conducted during site-specific planning and design.

## 4.3 Objectives

Objectives for the Proposed Action are statements of the desired outcome of the PEIS, as identified by the federal agencies and scoping comments. The resulting seven primary objectives include:

1. Allow greater flexibility in water management (related to refill, drawdown timing, and other water management measures).
2. Increase opportunities for the creation of nature-based structures during maintenance of USACE-owned revetments (structures that help prevent bank erosion).
3. Allow greater flexibility in hydropower production.
4. Increase ESA-listed fish passage survival at WVS dams.
5. Improve water management during the conservation season to benefit anadromous ESA-listed fish and other authorized project purposes.
6. Reduce pollutant levels to restore impaired water quality associated with the WVS dams to benefit anadromous ESA-listed species.
7. Reduce spawning and rearing habitat competition caused by hatchery fish.

The identification of these objectives, along with the PEIS purpose and need, guided the development of a reasonable range of alternatives.

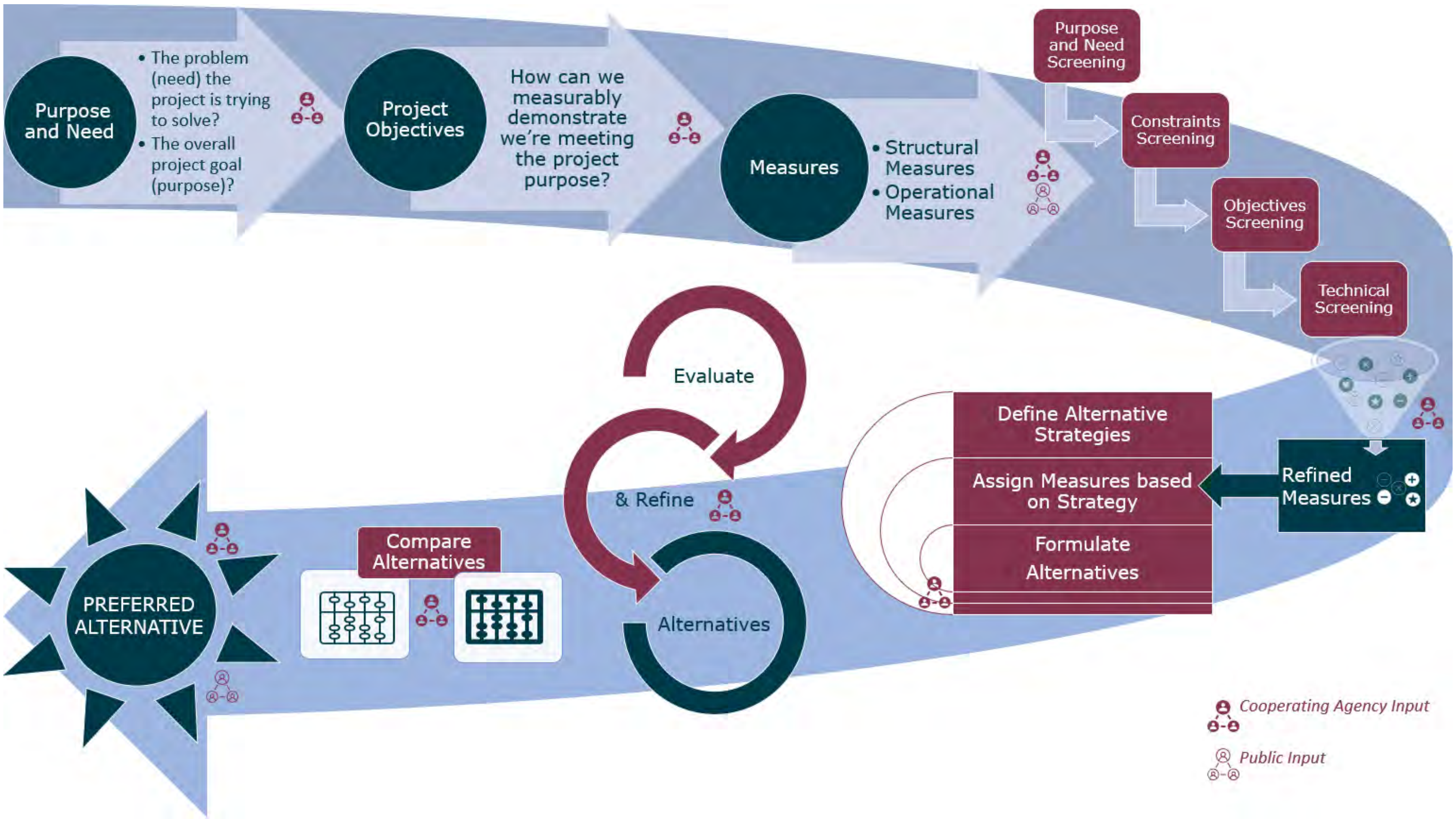


**Figure ES- 13. Diagram of Planning Process Leading to Selection of a Preferred Alternative**

## 4.4 Measures and Alternatives

Using public comments, internal cross-disciplinary working groups, and input from cooperating agencies, the USACE PEIS team identified and compiled a list of operational and structural measures, or actions, that meet seven objectives USACE developed for the Proposed Action. A measure is the action an agency would take to achieve a given objective. It describes either a physical (structural) change requiring construction or an operational change, usually in a precise location, that meets an objective, in whole or in part.

The team screened out potential measures based on criteria for meeting purpose and need for the project, achieving stated objectives, and technical considerations. The team then fashioned alternatives using combinations of the remaining measures around unifying themes or strategies. An alternative is a combination of one or more measures that, together, would address one or more of the objectives.

Building alternatives was an iterative process that increased the level of detail at each step to inform decisions concerning which alternatives to carry forward for analysis and consideration. Following initial modeling and evaluation of preliminary alternatives, new refined alternatives were developed to assess modified combinations of measures, and to distinguish the tradeoffs associated with key measures. Each alternative has an overall strategy that places emphasizes project objectives differently. **Table ES-4** summarizes the alternative strategies and associated project objectives.

After multiple rounds of screening, the measures that demonstrated the best outcomes for meeting project objectives were then compiled and bundled into a hybrid alternative (Alternative 5) that represents a fusion of the other four action alternatives.

**Table ES- 5. Project Alternative Strategies and Associated Objectives**

| Alternative | Strategy | Objectives[1] |
|---|---|---|
| No Action | Current O&M Practices | 1, 5 |
| 1 | Improve Fish Passage Through Storage-Focused Measures: Increase the probability of refilling WVS reservoirs and supplemental water delivery for authorized purposes | 1, 5 |
| 2A & 2B | Integrated Water Management Flexibility and ESA-Listed Fish Alternative | 1, 4, 6 |
| 3A & 3B | Operations Focused: Improve passage of ESA-listed fish through existing structures by modifying water control operations | 1, 4, 5, 6 |
| 4 | Structures Focused: Improve passage of ESA-listed fish by constructing fish passage and temperature control structures | 2, 4, 5, 6, 7 |
| 5 | Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative - Preferred Alternative | 1, 4, 6 |

[1]Proposed Action Objectives

1. Allow greater flexibility in water management (related to refill, drawdown timing, and other water management measures).
2. Increase opportunities for the creation of nature-based structures during maintenance of USACE-owned revetments (structures that help prevent bank erosion).
3. Allow greater flexibility in hydropower production.
4. Increase anadromous ESA-listed fish passage survival at WVS dams.
5. Improve water management during the conservation season to benefit anadromous ESA-listed fish and other authorized project purposes.
6. Reduce pollutant levels to restore impaired water quality associated with the WVS dams to benefit anadromous ESA-listed species.
7. Reduce spawning and rearing habitat competition caused by hatchery fish.

## 4.5 Assessment and Comparison of alternatives

The potential effects associated with each of the alternatives are analyzed under the following resource topics in Chapter 3 and 4 of the PEIS:

- Hydrologic Processes and River Infrastructure
- River Mechanics and Geomorphology
- Geology and Soils
- Water Quality
- Vegetation
- Wetlands
- Fish and Aquatic Habitat (including ESA-listed species and critical habitat)
- Wildlife, Birds, and Terrestrial Habitat (including ESA/sensitive species and critical habitat)
- Air Quality
- Socioeconomics
- Power and Transmission
- Water Supply (Irrigation, Municipal, and Industrial)
- Recreation
- Land Use
- Hazardous Materials
- Public Health and Safety – Hazardous Algal Blooms
- Public Health and Safety – Hazardous, Toxic, and Radioactive Waste
- Public Health and Safety – Drinking Water
- Environmental Justice
- Cultural Resources
- Visual Resources
- Noise
- Tribal Resources

For each of these resource topics and for each alternative, direct and indirect impacts or effects (environmental consequences) in Chapter 3. Direct effects are those caused by an action and occur at the same time and place. Indirect effects are those which occur later in time and/or are further removed in space (physical distance), but which are still reasonably foreseeable; indirect effects also include “induced changes” in the natural and human environments. Cumulative effects on all resources are addressed in Chapter 4. Cumulative effects are the interactive and additive effects on each of the resource topics from each alternative when combined with relevant past, present, and reasonably foreseeable future actions. All effects were assessed according to their magnitude, duration, and/or geographic extent. Effects could be considered either beneficial, adverse, both, or neither.

Programmatic analysis of the resource topics in Chapter 3 is at a broad and macroscopic scale and scope. This analysis of the resource topics focuses on the effects that are relevant at the broad scale and would factor into the decision to select the suite of measures to include in the Preferred Alternative. USACE will conduct subsequent NEPA analyses of future site-specific actions. Additional information on how USACE intends to conduct subsequent site-specific NEPA analysis and environmental compliance is in Chapter 7.

Upon completion of the effects analysis, USACE compared the benefits, environmental consequences, and tradeoffs of each of the alternatives (i.e., no-action and action alternatives). USACE developed multiple criteria to evaluate how effectively each alternative met the PEIS objectives, while considering costs and environmental, economic, and social effects. USACE then performed a tradeoff analysis using these criteria to compare the alternatives. To develop criteria, USACE considered the benefits and environmental and social consequences as reflected in Chapters 3 and 4 of the PEIS and then assessed the tradeoffs presented under each alternative within and outside of current authorities. Descriptions of the criteria, the procedure for comparing PEIS alternatives, and the results of that comparison are discussed in detail in Chapter 5 of the PEIS.

# 5 ALTERNATIVES AND COMPARISON OF EFFECTS

The sections below describe in sequence, the measures common to all alternatives, near term operational measures, and the alternatives and their effects.

## 5.1 Measures common to all Alternatives

Measures common to all action alternatives are those that would be implemented regardless of the action alternative selected because the effects would be consistent across the alternatives and do not provide a basis for differentiating between alternatives or selecting a preferred alternative. Measures common to all action alternatives include both operational measures and structural measures in multiple locations throughout the WVS. They also include new measures, existing operations, and O&M activities that would be carried forward.

As described in Section 2.4.2 of the PEIS, new measures common to all action alternatives include:

- Gravel augmentation in the North Santiam, South Santiam, and McKenzie River Basins below Big Cliff, Foster, Cougar, and Blue River Dams;
- Adaptation of the Hatchery Program;
- Maintenance of revetments considering nature-based engineering or alter revetments for aquatic ecosystem restoration;
- Maintenance of Existing and New Fish Release Sites above Dams; and
- Adaptive Management and Governance Framework.

As described in Section 2.4.4 of the PEIS, existing operations that would continue under all alternatives include:

- The drawdown at Fall Creek Reservoir for downstream fish passage;
- O&M of existing Adult Fish Facilities; and
- Operation, Maintenance, Repair, Replacement, and Rehabilitation of existing facilities

## 5.2 Near Term Operational Measures

As described in Section 2.2.5 of the PEIS, USACE is evaluating a suite of near-term operations until the structural measures in Alternatives 2A, 2B, 3A, 3B, 4, and 5 supersede or replace a near-term operation at a particular location. When all the structural measures in the selected alternative is implemented, any remaining near-term operations will cease. Where and when the suite of near-term operations is superseded or replaced by measures in Preferred Alternative is provided in the Implementation Plan for demonstrative purposes. It will be updated to reflect the selected action based on public input and the ongoing ESA consultation. The Implementation Plan is summarized in Section 5.4 of the PEIS and described in detail in Appendix N.

## 5.3 No Action Alternative

The No Action Alternative (NAA) is required by NEPA to provide the existing condition or baseline for comparison of environmental effects of the action alternatives. For the WVS, as described in Section 2.4.1 of the PEIS, the NAA consists of the ongoing O&M actions within the WVS at the start of this effort in the spring of 2019 and would have no change from current management direction or level of management intensity. These actions (measures) include water quality operations, flow operations, and downstream and upstream passage operations. For example, water would continue to be discharged through powerhouses to reduce or dilute the total dissolve gas (TDG) generated from use of spillways (**Figure ES-14**) or regulating outlets (ROs); existing adult fish facilities would continue to be operated and maintained (**Figure ES-15**); and returning adult salmonids would continue to be transported past dams and released in stream reaches above WVS reservoirs (**Figure ES-16**). Actions and operations occurring in the WVS would also include those agreed to in previous ESA consultations between USACE and the Services (NMFS and USFWS).

The NAA does not meet the purpose and need of the project because the current operating conditions of the WVS adversely affect ESA-listed fish species, specifically UWR Chinook salmon, UWR steelhead, and bull trout, and the designated critical habitat for these species.

**Figure ES- 14. Spillway and powerhouse at Detroit Dam**

**Figure ES- 15. Minto Adult Fish Facility downstream of Big Cliff Dam**

**Figure ES- 16. Releasing trout into the McKenzie River**

## 5.4 Effects of the NAA

Under the NAA, there would be no to negligible effect on hydrologic processes or flows downstream. However, this means that the NAA would not appreciably allow greater flexibility in water management related to refill, drawdown timing, and other water management measures. Because the WVS would be operated as designed and there would be no new structural modifications that would increase operational complexity, there is a low mechanical and operational risk associated with the NAA.

The estimated total annual cost estimate for the NAA is $9,279 million. The cost of each alternative, including the NAA, was evaluated using the annual costs over the 50-year period of analysis in 2021 dollars. The annual cost includes annualized first costs for design and construction as well as the annual cost for Operations, Maintenance, Repair, Replacement and Rehabilitation.

Under the NAA, power generation for combined WVS projects would continue to be marginally economically viable. The Net Present Value (NPV) for the combined WVS is about $225 million. NVP assesses the long-term economic viability of the hydropower plants (given implementation of the alternative. Reservoir storage would result in enough stored water to meet the Municipal and Industrial (M&I) and irrigation demands in almost all years. Water would be released from the reservoirs to satisfy projected demands of stored water for M&I uses at the 2050 demand level and existing (as of April 2019) irrigation water service contracts. Additionally, the recreational experience at WVS reservoirs would not change compared to baseline or current conditions, there would be no effects to average annual visits or average annual benefits, and no changes to the number of full-time jobs or the regional economic development. Overall, the NAA would perform well for hydropower and recreational interests and have marginal benefits to water storage compared to most of the action alternatives.

The NAA is deficient in meeting the ESA species focused Proposed Action objectives (objectives 4-6). Of the four extant UWR spring Chinook salmon populations (North Santiam, South Santiam, McKenzie, Middle Fork Willamette), two populations would decline and only one population would have high persistence (i.e., have low risk of extinction). In addition, under the NAA the Legacy McKenzie Chinook population would be at risk and there would be major adverse effects to the winter steelhead resulting in a high risk of extinction. The NAA would not result in habitat gains for bull trout and it is the lowest ranked of all alternatives for downstream survival.

USACE must comply with the ESA to continue to operate and maintain the WVS so the NAA cannot be selected as the Preferred Alternative. The primary purpose of the NAA in this PEIS is to serve as a reference case or baseline against which to compare the relative benefits and adverse impacts of the action alternatives.

## 5.5 Alternative 1. Improve Fish Passage Through Storage-Focused Measures

The purpose of Alternative 1, also referred to as the Project Storage Alternative, is to maximize the refill volumes of conservation pools at WVS reservoirs to meet authorized purposes that depend on full reservoirs, including M&I and irrigation water supply, recreation, and water quality, as well as to improve fish passage through the WVS dams to increase the survival of ESA-listed fish species. A detailed description of Alternative 1 is provided in Section 2.4.5 of the PEIS.

Alternative 1 is designed to increase the probability of refilling the WVS reservoirs and to use a greater portion of the total reservoir volume for conservation storage, including the inactive and power pools. There are also changes in regulated hydrology throughout the conservation season because the goal of Alternative 1 is to fill the reservoirs as often as possible and supply water from storage as long as possible late into the conservation season.

The main operational features of Alternative 1 are to reduce minimum flows to congressionally authorized minimum flow requirements as well as to augment instream flows by using the power and inactive pools. Alternative 1 also proposes only structural measures for fish passage and water quality, such as the Floating Screen Structure (FSS) shown in **Figure ES-22**.

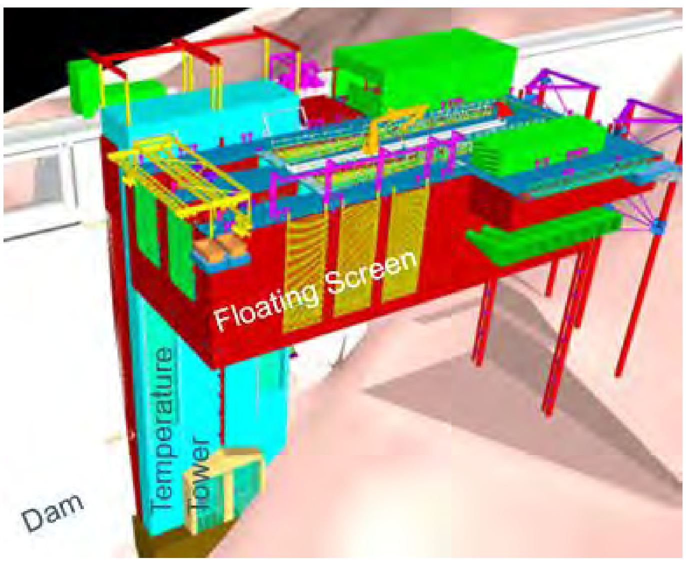


**Figure ES- 22. Schematic of a Floating Screen Structure to facilitate downstream fish passage**

## 5.6 Effects of Alternative 1

Alternative 1 is the second most expensive alternative, exceeded only by Alternative 4. This high cost is primarily driven by the cost to design, construct, operate, and maintain structural measures for temperature control, fish passage, and TDG abatement. The estimated total annual cost for Alternative 1 is $104,396 million, $95 million greater than the NAA

Under Alternative 1, flows would be reduced minimum flows to congressionally authorized minimum flow requirements which would allow for the greatest increase in total storage of all the alternatives. These flow operations replace the 2008 BiOp flows in the NAA. Additionally, many of the structural measures allow for fish passage and temperature management that do not result in lower reservoir elevations in the spring through fall. Thus, there would be a moderate beneficial effect to M&I water supply and irrigation users of the conservation storage space.

The increase in total storage and flow measures would result in the same or higher downstream flows in the summer compared to the NAA. Flow in the mainstem at Salem would be lower than in the NAA from mid-May through June, but flows would still be high and above 6,000 cubic feet per second (cfs). During the summer, flow at Salem would be higher than in the NAA, rarely dipping below 6,000 cfs, resulting in a minor beneficial effect to existing M&I water supply and irrigation users from increased summer flows during the driest years.

The additional storage in combination with water quality and fish passage structures that allow greater operational flexibility under Alternative 1 would contribute to an overall potential increase in average annual hydropower generation of 8 aMW (8 megawatts of power generated continuously over a year, or roughly enough to power 6,371 households annually). However, the high capital and O&M cost of Alternative 1 would result in the second greatest decrease in NPV from that provided by the NAA. Under Alternative 1, there would be a $1.159 billion reduction in NPV to -$934 million. Therefore, there would be long-term, major, adverse effects on economic viability of WVS power generation. There would, however, be negligible risk to local hydropower generation at Hills Creek and Cougar dams (**Figure ES-23**), which would continue to be able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages resulting from weather events or fires.

**Figure ES- 23. Hydropower transmission lines leaving Cougar Dam**

Under Alternative 1, the additional storage and reduction in minimum flows would mean the reservoirs stay higher for more of the conservation season resulting in minor to moderate benefits to reservoir recreation. This translates into slight increases in annual WVS reservoir visitations, resulting in an approximate increase of $300,000 in annual economic benefits (a 1.5% increase) compared to the NAA. The regional economic development from recreation effects would be low. The regional economic impacts are associated with the negligible impacts to employment and regional output.

Despite large spending on structural measures, Alternative 1 only marginally meets the ESA-focused Proposed Action objectives (objectives 4-6). Although Alternative 1 did rank highest out of all alternatives for downstream survival and three out of four UWR spring Chinook salmon populations would reach replacement, only two out of four UWR spring Chinook salmon populations would have high persistence (e.g., a low risk of extinction). Additionally, the McKenzie Core Legacy UWR spring Chinook salmon population would remain at risk of extinction. There would also be the least habitat gains for bull trout compared to the NAA due to lack of effective downstream passage at Cougar.

Overall, due to the scale of actions required under Alternative 1, this is the second most expensive alternative. The high cost makes it unlikely this alternative would be acceptable to many stakeholders, agencies, and the public. This is compounded by the fact that Alternative 1 would result in fewer benefits to ESA species than several less costly alternatives, including Alternatives 2A, 2B, and 5. Therefore, Alternative 1 was not identified as the Preferred Alternative.

## 5.7 Alternative 2A. Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam)

Alternatives 2A, also referred to as the Hybrid Alternative with Cougar FSS, was developed to improve fish passage through the WVS dams using a combination of modified operations and structural improvements, along with other measures to balance water management flexibility and meet ESA-listed fish obligations. A detailed description of Alternative 2A is provided in Section 2.4.6 of the PEIS. In Alternative 2A, the "Integrated Temperature and Habitat Flow Regime" operation replaces the 2008 BiOp flows in the NAA. This would shift the release of stored water from the spring to the summer and fall, most prominently in dry years. Flows would be reduced within a range down to minimums needed for fish survival when reservoirs are under 90% of rule curve elevation. While these minimums are less than the BiOp targets, these are adaptive within a water year and can return to levels that are higher than the BiOp flows if reservoir levels are high. Alternatives 2B, 3A, 3B, and 4 also include this flow measure.

The other main operational feature of Alternative 2A is the augmentation of instream flows by using the power and inactive pools. Alternative 2A also proposes a combination of structural measures for fish passage and temperature control. Alternative 2A does not include the structural improvements for TDG abatement found in Alternatives 1 and 4 or the fish passage and temperature structures at Hills Creek Dam found in Alternative 4. In contrast to Alternative 1 but like all other alternatives, Alternative 2A proposes operational measures utilizing the spillway and ROs for temperature management at Green Peter (**Figure ES-24**). Alternative 2A also includes a deep fall drawdown and spring spillway operations for fish passage at Green Peter, like Alternatives 2B, 3A, 3B, and 5. The only difference between Alternative 2A and 2B is in their downstream passage measure at Cougar Dam. As its name states, Alternative 2A proposes structural downstream fish passage at Cougar Dam where as Alternatives 2B proposes operational fish passage at Cougar Dam that would require significant structural components. Alternative 5 also has this difference as well as proposing a refined flow operation that slightly differs from the "Integrated Temperature and Habitat Flow Regime" operation in Alternatives 2A through 4.

**Figure ES- 24. Green Peter spillways in action on May 20, 2019**

## 5.8 Effects of Alternative 2A

Alternative 2A is the third costliest alternative (surpassed by Alternative 1 and 4) due to the numerous structural measures included. The estimated total annual cost for Alternative 2A is $67,561 million, $58 million greater than the NAA.

Alternative 2A would shift the release of stored water from the spring to the summer and fall, most prominently in dry years. The "Integrated Temperature and Habitat Flow Regime" would replace the 2008 NMFS BiOp in the NAA. Briefly, this would modify the base flow targets at a WVS reservoir if it is at more or less than 90 percent of rule curve elevation. Flows would be reduced within a range down to minimums needed for fish survival when reservoirs are under the 90 percent threshold. While these minimums would be less the BiOp targets in the NAA, these would be adaptive within a water year and could return to levels that are actually higher than the BiOp flows if reservoir levels are high.

This operation is designed to increase access to habitat through providing additional conversation storage to help manage temperatures later in the conservation season. The increase in total storage and flow measures results in the same or higher downstream flows in the summer compared to the NAA. The Integrated Flow Regime would require additional flow through June based on the air temperature, compared to the 2008 BiOp flows proposed under the NAA. Therefore, flows later in the summer and fall would be higher than the NAA due to the additional accumulated stored water. Under Alternative 2A, flow in the mainstem at Salem would be lower than in the NAA from April through June about 25% of the time, but flows would still be high, usually above 10,000 cfs. During the summer, flow at Salem would be higher than in the NAA, rarely dropping below 6,000 cfs. Alternative 2A would have a negligible effect to existing water rights for M&I water supply and irrigation in the spring and would have a minor incidental beneficial effect in the summer by increasing summer flows in the driest years.

The additional storage under Alternative 2A would contribute to an overall increase in average annual hydropower generation by 4 aMW (roughly enough to power 3,185 households annually). However, the high capital and O&M cost of Alternative 2A results in the greatest decrease in NPV from that provided by the NAA. Under Alternative 2A, there would be a $863 million reduction in NPV to -$638 million. Therefore, there would be long-term, major, adverse effects on economic viability of WVS power generation. However, there would be negligible risk to local hydropower generation, since Hills Creek and Cougar dams would continue to be able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages resulting from weather events or fires.

Under Alternative 2A, reservoirs stay higher for more of the conservation season, resulting in minor to moderate benefits to reservoir recreation. This translates into slight increases in annual visitations, resulting in an approximate increase of $169,000 in annual economic benefits (a 0.83% increase) compared to the NAA. The regional economic impact from recreation effects would be medium. The regional economic impacts are associated with the potential loss of 1.7 jobs in the South Santiam Basin due to the drawdown at Green Peter and a moderate reduction in regional output.

Alternative 2A most effectively meets the ESA focused Proposed Action objectives (objectives 4-6) of any alternative. It ranks second for downstream survival with all four UWR Chinook salmon populations reaching replacement, and three out of four UWR Chinook salmon populations with high persistence (e.g., low risk of extinction). Alternative 2A also reduces the risk to the McKenzie Core Legacy population and provides more habitat gains for bull trout compared to the NAA due to the inclusion of effective downstream passage at Cougar.

In contrast to Alternative 2A, Alternatives 2B and 5 result in only two of the three UWR Chinook populations with high persistence. This is the biggest difference in how Alternative 2A performs for the ESA objectives compared to these other two alternatives. Alternative 2A is almost identical to Alternatives 2B and 5. The major difference in measures between Alternative 2A and Alternatives 2B and 5 is the downstream fish passage measure proposed at Cougar Dam. Alternative 2A proposes a FSS and Alternatives 2B and 5 propose a deep drawdown to pass fish through the Diversion Tunnel. The difference in the number of populations with high persistence is because the ESA models assume increases in downstream survival with a structure at Cougar Dam than through a deep drawdown operation.

Although 2A performs the best at meeting the ESA focused Proposed Action objectives (objectives 4-6), USACE deemed Alternatives 2A, 2B, and 5 very comparable in the beneficial impact for ESA listed species. However, Alternative 2A is slightly less certain in meeting ESA focused objectives at Cougar compared to Alternatives 2B and 5. This is due to the uncertainty associated with how well the FSS would collect fish.

Currently, there are few existing FSSs on which to base predictions on how well this type of structure would collect fish at Cougar Dam. Existing evidence highlights the wide variation in performance for these structures, and there is little data available for existing FSS's where Chinook are present upon which to base the Cougar FSS designs. This is in large part because the FSS at Cougar would have to operate at a large range of depths and would be located within a narrow cul-de-sac of the reservoir. No other existing FSSs collect fish at the magnitude of depth ranges that would be required or have the physical site constraints present at Cougar Reservoir. Finally, if collection rates proved to be low with an FSS at Cougar there are minimal post-operation mitigation options for improving collection with currently available technology.

The uncertainty that an FSS would effectively collect juvenile fish migrating downstream at Cougar Dam – coupled with uncertain mitigation options to improve such a structure-compounded with the high cost to design, construct and operate the facility, lead USACE to not select Alternative 2A as the Preferred Alternative.

## 5.9 Alternative 2B. Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)

Alternative 2B, also referred to as the Hybrid Alternative with Cougar Diversion Tunnel Modification, was developed to improve fish passage through the WVS dams using a combination of modified operations and structural improvements, along with other measures to balance water management flexibility and meet ESA-listed fish obligations. A detailed description of Alternative 2B is provided in Section 2.4.7 of the PEIS. Alternative 2B is almost exactly like Alternative 2A and 5. The difference between Alternatives 2A and 2B is the fish passage measure at Cougar Dam. Alternative 2A uses a structure that operates with existing reservoir fluctuations to pass fish downstream, whereas Alternative 2B includes an operation where the reservoir is drawn down to use the diversion tunnel to pass fish (**Figures ES-25 and ES-26**). Alternative 5 also differs from Alternative 2B by proposing a refined flow operation that modifies from the "Integrated Temperature and Habitat Flow Regime" operation in Alternatives 2A through 4 based on discussions with cooperators on how the "Integrated Temperature and Habitat Flow Regime" could be improved to better meet the species needs during the lowest low flows.

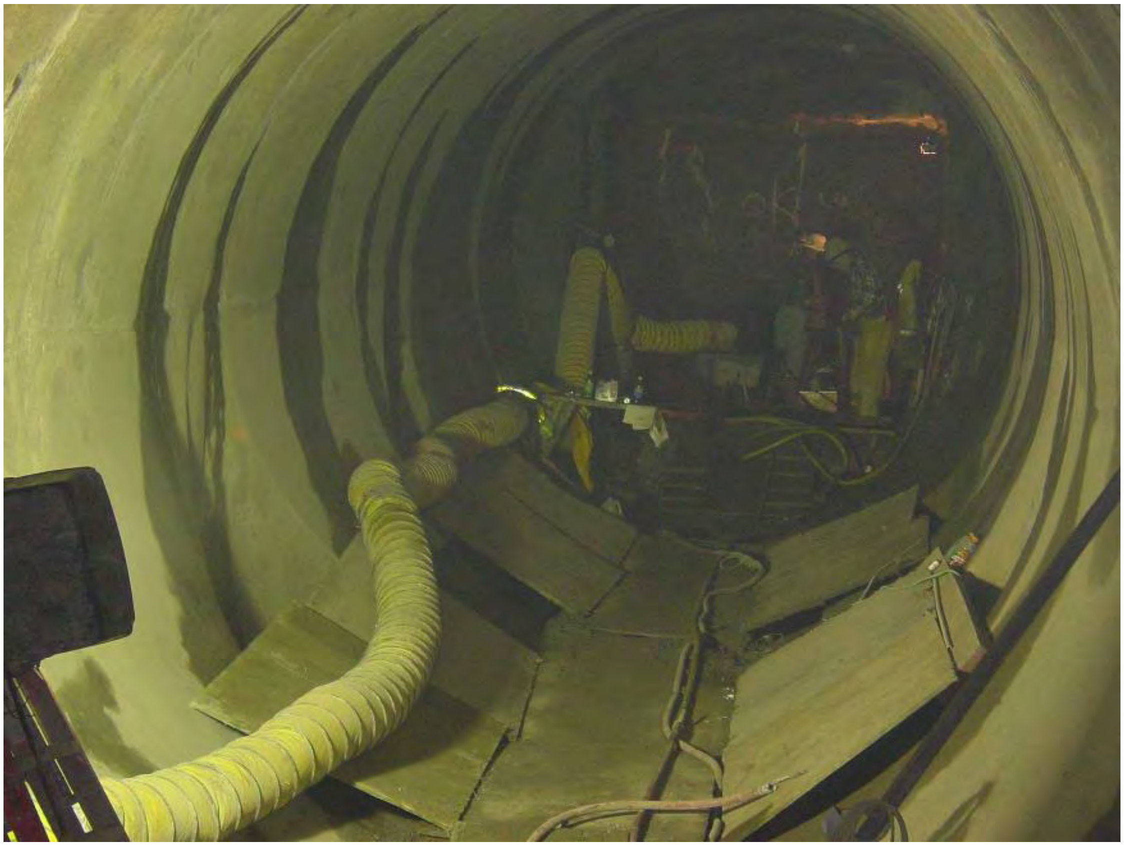

**Figure ES- 25. Working inside the Cougar diversion tunnel**


**Figure ES- 26. Downstream view of Cougar diversion tunnel in action in 2016**

## 5.10 Effects of Alternative 2B

Alternative 2B would be the fourth costliest alternative to implement (surpassed by Alternatives 1, 2A, and 4) due to the incorporation of numerous structural measures. The estimated total annual cost for Alternative 2B is $62,291 million, $53 million greater than the NAA.

Under Alternative 2B, there is an estimated decrease in total system-wide storage of 64,000 acre-feet from the NAA (1,640,000 acre-feet) primarily due to the diversion tunnel fish passage operation at Cougar. The small decrease in system-wide conservation storage would have a minor adverse effect to M&I water supply and irrigation users of the conservation storage.

Under Alternative 2B, flow targets in the summer and fall would be met more frequently due to the additional accumulated stored water at WVS reservoirs other than Cougar and Green Peter. However, compared to NAA, the spring and early summer flows are similar or somewhat lower across the WVS. This is a result of the spring drawdown at Cougar Dam that occurs during the NAA refill period. The reduced storage at Cougar means that other WVS reservoirs, notably in the Middle Fork of the Willamette River subbasin, would be required to release additional water to meet mainstem Willamette River flow targets.

The drawdown of the Cougar Reservoir would effectively eliminate the use of stored water for water supply from Cougar. However, the Blue River Reservoir would fill more than under the NAA, partially offsetting the lost storage from Cougar Reservoir. Cougar Dam is also situated on the South Fork of the McKenzie River, and its flow is a small portion of the overall McKenzie River flow. The flow on the McKenzie River would be only slightly less in the driest years as compared to the NAA due to additional flow from Blue River. Therefore, Alternative 2B would have a negligible effect to live flow water rights in the McKenzie sub-basin. Due to the expected limited level of demand for stored water on the McKenzie River, Alternative 2B would be expected to have only a minor adverse effect to M&I water supply and irrigation users in the McKenzie sub-basin.

The decrease in storage would contribute to an overall decrease in average annual hydropower generation by 18 aMW (roughly enough to power 14,334 households annually). This, coupled with the high cost of Alternative 2B, results in a $933 million reduction in NPV to -$638 million. Therefore, there would be long-term, major, adverse effects on economic viability of WVS power generation. In addition, the fish passage operation at Cougar Dam would result in infrequent, temporary major adverse effects on transmission services to Blue River. Deep fall and spring drawdowns would compromise Cougar Dam's ability to operate islanded (isolated) and serve this community under temporary weather or fire related outage conditions. Generation at Hills Creek Dam would remain able to operate islanded (isolated), providing transmission services to Oakridge, like the NAA.

Although there would be a negligible adverse effect on recreation across the WVS, the decrease in storage at Cougar Reservoir would result in major adverse effects to reservoir recreation at this location. However, as there are no jobs associated with recreation at Cougar Reservoir, the regional economic effects remain similar to those under Alternative 2A. Alternative 2B results in the smallest increases in annual visitations, resulting in an approximate increase of $12,000 in annual economic benefits (a 0.06% increase) compared to the NAA. The regional economic impact from recreation effects is medium. The regional economic impacts are associated with the potential loss of 1.7 jobs in the South Santiam Basin due to the drawdown at Green Peter and a moderate reduction in regional output.

Alternative 2B effectively meets the ESA focused Proposed Action objectives (objectives 4-6), surpassed only by Alternative 2A. Alternative 2B ranks fourth for downstream survival with all Chinook populations reaching replacement. Alternative 2B also reduces risk to the McKenzie Core Legacy population and provides more habitat gains for bull trout compared to the NAA due to the inclusion of effective downstream passage at Cougar. In contrast to Alternative 2A, Alternative 2B results in only three of the four Chinook populations with high persistence. This is the biggest difference in how Alternative 2B performs for the ESA focused Proposed Action objectives compared to Alternative 2A, a result of the downstream fish passage measure proposed at Cougar Dam. The difference in the number of populations with high persistence is because the ESA models assumes increases in downstream survival with a structure at Cougar Dam than through a deep drawdown operation.

There is some uncertainty due to the major modifications to the existing infrastructure at Cougar that would need to occur to use the diversion tunnel as a regular outlet for the Dam. The diversion tunnel was originally constructed to be used temporarily during dam construction and was not designed to be operated on a regular basis. Without detailed investigation and designs, the dam safety and operational feasibility of drawing down to the diversion tunnel annually for fish passage is uncertain. However, unlike the FSS for which there are currently no known mitigation actions for addressing the fish collection risks, there are clear engineering pathways for managing risk associated with dam safety and operational feasibility of a dam outlet.

In sum, Alternative 2B effectively meets the ESA focused Proposed Action objectives (objectives 4-6) at lower risk and substantially lower costs than Alternative 2A. However, Alternative 2B was not chosen as the Preferred Alternative because conversations with cooperators resulted in refinements to the “Integrated Temperature and Habitat Flow Regime” operation. These refinements are included in Alternative 5, the Preferred Alternative. Alternative 2B is identical to Alternative 5 but for these refinements to the “Integrated Temperature and Habitat Flow Regime” measure.

## 5.11 Alternative 3A. Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)

Alternatives 3A, also referred to as the Operations-Focused Fish Passage Alternative, would primarily use WVS dam operations for water quality and fish passage. A detailed description of Alternative 3A is provided in Section 2.4.8 of the PEIS. Alternative 3A does not include structural measures for temperature control, TDG abatement, or downstream fish passage like Alternatives 1 and 4 and much of Alternatives 2A, 2B, and 5. An important part of the operational focus is the increased use of different flow outlets from the dams to control temperature, with the spillway supplying warmer water from the upper reservoir and the deeper outlets – ROs and turbines – supplying cooler water. Alternative 3A would also implement spring and fall drawdowns at some WVS reservoirs for volitional downstream fish passage. Additionally, where Alternative 1, 2A, 2B, 4, and 5 only proposed a new adult fish facility for upstream fish passage at Green Peter Dam, Alternative 3A proposes new adult fish facilities at Hills Creek and Blue River as well.

Alternative 3A is very similar to Alternative 3B, with different combinations of spring drawdowns and spring spill operations across the WVS for downstream fish passage. Alternatives 3A and 3B also differ in the drawdowns for fish passage operations at Cougar Dam. Under Alternative 3A, the spring and fall drawdowns would target the Cougar RO (**Figure ES-27**), whereas the Alternative 3B drawdowns would target the much lower diversion tunnel (like Alternatives 2B and 5). By making these distinctions between Alternatives 3A and 3B, the Draft PEIS allows for the unique impacts associated with each of these operations for downstream passage to be identified at Cougar and the tradeoffs between them to be assessed and compared, which was important to cooperators.

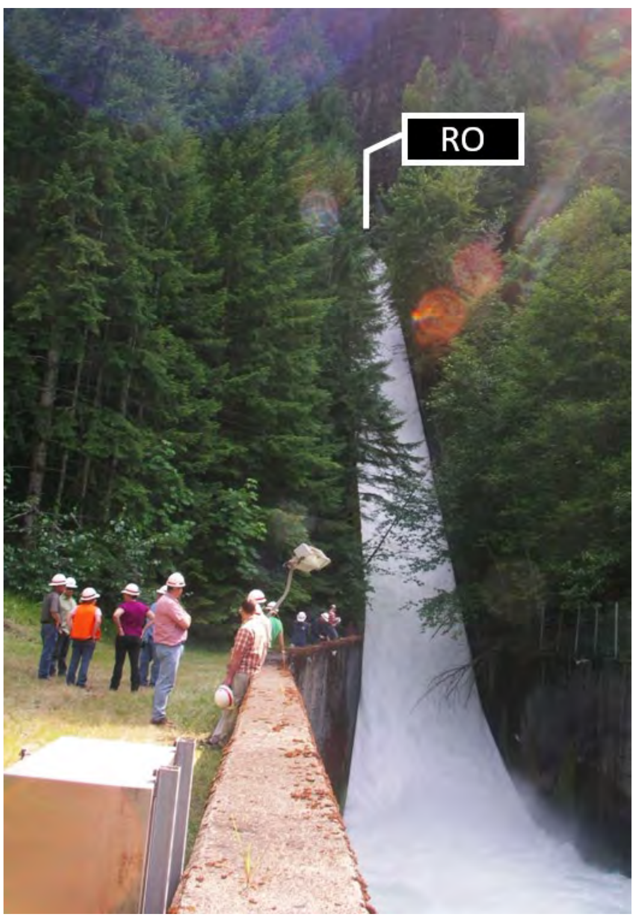


**Figure ES- 27. Cougar regulating outlet and RO channel in action**

Like Alternatives 2A, 2B, 3B, and 4, the "Integrated Temperature and Habitat Flow Regime" operation replaces the 2008 BiOp flows in the NAA under Alternative 3A. Alternative 3A also augments instream flows by using the power and inactive pools and allows reservoirs to draft below the NAA rule curves to meet minimum flow requirements. This usually occurs during the fall of drier years at reservoirs that do not have a fall drawdown operation.

## 5.12 Effects of Alternative 3A

Alternative 3A would be the least costly alternative to implement because it incorporates the fewest structural measures.  Alternative 3A would be approximately $86 million less annually than the costliest alternative, Alternative 4. The estimated total annual cost for Alternative 3A is $26,442 million, $17 million greater than the NAA.

By combining spring spill and drawdowns with fall drawdowns at six of the 11 storage projects, Alternative 3A has major adverse effects to system-wide conservation storage. These operations would result in a 56% reduction of system-wide storage compared to the NAA, or 590,000 acre-feet. Depending on how and when the Fish and Wildlife conservation storage allocation is takes priority over other consumptives uses it would leave very little conservation storage available for M&I water supply or AI. Therefore, Alternative 3A would have a major adverse effect to M&I water supply and irrigation.

In addition, under Alternative 3A, flows during dry years would be lower than in the NAA starting in April, dropping below 5,000 cfs in August. This would likely cause downstream water users in the system to be shut off more due to low flow conditions than under current conditions, resulting in a moderate adverse effect to M&I water supply and irrigation.

The decrease in storage would contribute to an overall decrease in average annual hydropower generation by 87 aMW (roughly enough to power 69,283 households annually). Coupled with the cost of Alternative 3A, there would be a $853 million reduction in median NPV to -$628 million. Therefore, there would be long-term, major, adverse effects on economic viability of WVS power generation. Additionally, the fish passage operations that reduce the power pool at Hills Creek and Cougar Dams would result in infrequent, temporary major adverse effects on transmission services to Oakridge and Blue River. Deep fall and spring drawdowns would compromise the Hills Creek and Cougar dams' respective abilities to serve these communities under temporary storm or fire related outage conditions.

Alternative 3A is one of two alternatives that results in decreases in annual visitations. This would be a major, long term adverse effect to recreation in the WVS, resulting in an approximate decrease of $769,000 in annual economic benefits (a 3.76% decrease) compared to the NAA. The effects to recreation would also have a high regional economic impact with close to a 50% reduction in recreation-related jobs in the North Santiam and Middle Fork Willamette subbasins and a reduction in regional output greater than $150,000 in multiple basins.

In addition to having adverse effects on hydropower, water supply, and recreation, Alternative 3A does not effectively meet all the ESA focused Proposed Action objectives (objectives 4-6). Although all four UWR Chinook salmon populations would reach replacement under Alternative 3A, only one out of four UWR Chinook salmon populations would have high persistence (e.g., low risk of extinction) which does not improve on the NAA. Additionally, Alternative 3A ranks fifth for downstream survival and the McKenzie Core Legacy population is at risk of extinction. However, there would be habitat gains for bull trout compared to the NAA.

Although one of the least costly alternatives, Alternative 3A performs poorly for the ESA focused Proposed Action objectives (objectives 4-6) while significantly decreasing total storage with adverse effects to hydropower, water supply, and recreation. Additionally, the deep fall and spring drawdowns would compromise the Hills Creek and Cougar dams' respective abilities to operate islanded and serve Blue River and Oak Ridge communities under temporary storm or fire related outage conditions. These adverse effects without appreciable benefits to ESA-listed species makes it unlikely this alternative would be acceptable to stakeholders, agencies, and the public. Therefore, Alternative 3A was not identified as the Preferred Alternative.

## 5.13 Alternative 3B. Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)

Alternatives 3B, also referred to as the Operations-Focused Fish Passage Alternative using Diversion Tunnel at Cougar, would primarily use WVS dam operations for water quality and fish passage (**Figures ES-28 and ES-29**). A detailed description of Alternative 3B is provided in Section 2.4.9 of the PEIS. Alternative 3B is very similar to Alternative 3A but differ on downstream fish passage operations in the spring and drawdowns for fish passage operations at Cougar Dam. Under Alternative 3B, the spring and fall drawdowns at Cougar Dam would target the diversion tunnel (like Alternatives 2B and 5), resulting in a much lower drawdown than Alternative 3A which proposes drawing down to the RO. By making these distinctions between Alternatives 3A and 3B, the Draft PEIS allows for the unique impacts associated with each of these operations for downstream passage to be identified at Cougar and the tradeoffs between them to be assessed and compared, which was important to cooperators.

## 5.14 Effects of Alternative 3B

Alternative 3B would be the second least costly alternative to implement due to incorporation of few structural measures. Alternative 3A would be the only less costly alternative in comparison. This is because Alternative 3B includes a lower drawdown operation at Cougar Dam that requires additional costs to modify the DT, as discussed under the Alternative 2B tradeoffs which also has a fish passage measure utilizing the DT at Cougar. The estimated total annual cost for Alternative 3B is $30,652 million, $21 million greater than the NAA.

By combining spring spill and drawdowns with fall drawdowns at 6 of the 11 storage projects, Alternative 3B would substantially affect the ability to store water system-wide. These operations would result in a 50% reduction of water stored system-wide compared to the NAA, or 669,000 acre-feet. Depending on how and when the Fish and Wildlife conservation storage allocation is takes priority over other consumptives uses it would leave very little conservation storage available for M&I water supply or AI. Therefore, Alternative 3B would have a major adverse effect to M&I water supply and irrigation.

**Figure ES- 28. Foster Dam spillway in action; operational spillway releases would be used at Foster and five other WVS dams in Alternative 3B**

**Figure ES- 29. Partial drawdown at Hills Creek Reservoir; under Alternative 3B, spring and/or fall drawdowns would occur at Hills Creek and five other WVS reservoirs**

Unlike Alternative 3A, the goal in Alternative 3B is to fill Detroit Reservoir for a spring spill fish passage operation; hence flows at Salem in Alternative 3B would rarely drop below 5,000 cfs in the summer, though they are lower than in the NAA in dry years. Alternative 3B includes a drawdown at Hills Creek instead of Lookout Point, so water flowing through Hills Creek can be stored in Lookout Point, preserving a larger amount of water than in Alternative 3A. However, the reduced flows compared to the NAA may cause some water users in the system to be shut off more than under current conditions, but not as much as in Alternative 3A.

The decrease in storage would contribute to an overall decrease in average annual hydropower generation by 79 aMW (roughly enough to power 62,912 households annually - see Section 3.12.3.2 for details). This, coupled with the cost of Alternative 3B, would result in a $829 million reduction in median NPV to -$604 million. Therefore, there would be long-term, major, adverse effects on economic viability of WVS power generation. Additionally, the fish passage operations at Hills Creek and Cougar Dams would result in infrequent, temporary major adverse effects on transmission services to Oakridge and Blue River. Deep fall and spring drawdowns would compromise the Hills Creek and Cougar dams' respective abilities to serve these communities under temporary storm or fire related outage conditions.

Alternative 3B results in the largest decreases in annual visitations. This would be a major, long term adverse effect to recreation in the WVB, resulting in an approximate decrease of $1,274,000 in annual economic benefits (a 6.23% decrease) compared to the NAA. The effects to recreation would also have a high regional economic impact with a 50% reduction in recreation related jobs in the South Santiam subbasin and a reduction in regional output greater than $150,000 in multiple basins.

In addition to having adverse effects on hydropower, water supply, and recreation, Alternative 3B does not effectively meet all the ESA focused Proposed Action objectives (objectives 4-6). Under Alternative 3B all four UWR Chinook salmon populations would reach replacement and two out of four UWR Chinook salmon populations would have high persistence (i.e., low risk of extinction). However, Alternative 3B ranks sixth for downstream survival (the lowest ranking of the action alternatives). Additionally, the McKenzie Core Legacy population would be at risk of extinction and there would be no habitat gains for bull trout compared to the NAA.

Although one of the least costly alternatives, Alternative 3B performs poorly for ESA focused Proposed Action objectives (objectives 4-6) while significantly decreasing total storage with adverse effects to hydropower, water supply, and recreation. Additionally, the deep fall and spring drawdowns would compromise the Hills Creek and Cougar dams' respective abilities to provide electricity to nearby communities under temporary storm or fire related outage conditions. These adverse effects, without appreciable benefits to ESA-listed species makes it unlikely this alternative would be acceptable to stakeholders, agencies, and the public. Therefore, Alternative 3B was not identified as the Preferred Alternative.

## 5.15 Alternative 4. Improve Fish Passage with Structures-Based Approach

Alternative 4 takes a structures-based approach to improve fish passage through the WVS dams to increase the survival of ESA-listed fish. A detailed description of Alternative 4 is provided in Section 2.4.10 of the PEIS. Like Alternative 1, Alternative 4 proposes only structures for water quality and downstream fish passage, shifting the release of stored water from the spring into the summer and fall and augmenting instream flows by using the power and inactive pools. In contrast to Alternative 1, Alternative 4 proposes the “Integrated Temperature and Habitat Flow Regime” operation, the targets of which are generally higher and more variable than those in the congressionally authorized minimum flow requirements proposed under Alternative 1. As its name and purpose imply, Alternative 4 also proposes the most structural measures for fish passage and water quality of any alternative.

In contrast to Alternative 1, Alternative 4 includes a fish passage structure and water temperature control tower at Hills Creek Dam (**Figure ES-30**) and a fish passage structure at Cougar Dam but replaces the water temperature control tower at Green Peter Dam proposed in Alternative 1 with using operational measures to utilize the spillway and ROs for temperature management. In contrast to Alternative 1, 2A, 2B, and 5, Alternative 4 proposes an upstream passage structure at Hills Creek Dam and not at Green Peter Dam. These are the defining differences for comparison of the relative costs and benefits associated with the different combinations of structural measures.

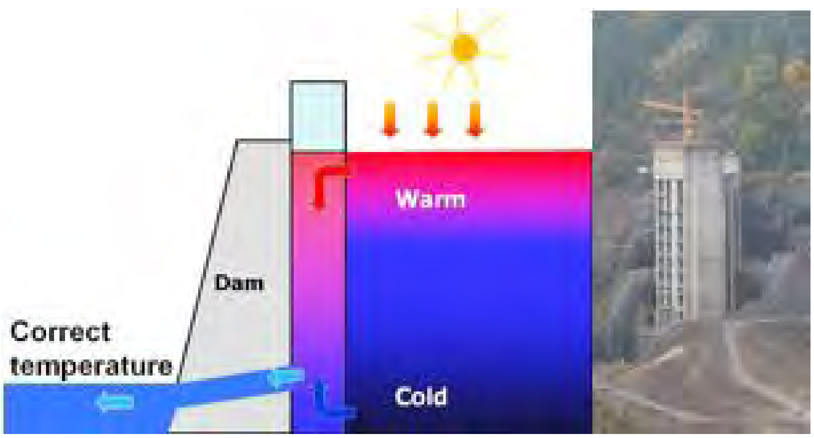


**Figure ES- 30. Schematic of water temperature control tower and actual tower under construction at Cougar Dam; under Alternative 4, water temperature control towers are proposed at 4 dams**

## 5.16 Effects of Alternative 4

Alternative 4 would be the costliest alternative to implement, primarily driven by the cost to design, construct, operate, and maintain the structural measures for temperature control, fish passage, and TDG abatement. Alternative 4 proposes the most structural measures of any alternative. The estimated total annual cost for Alternative 4 is $113,001 million, $104 million greater than the NAA.

Under Alternative 4, like Alterative 2A, there is an estimated increase in total storage of 122,000 acre-feet from the NAA. The combination of lower spring flow targets and no reservoir drawdowns during the conservation season would allow for the increase from the NAA in stored water. The Integrated Flow Regime would require additional flow based on the air temperature, compared to the 2008 BiOp flows implemented under the NAA. Therefore, flows later in the summer and fall would be higher than the NAA due to the additional accumulated stored water.

The additional storage would contribute to an overall slight increase in average annual hydropower generation by 1 aMW (roughly enough to power 796 households annually - see Section 3.12.3.7 for details). However, the high capital and O&M cost of Alternative 4 results in the second greatest decrease in NPV from that provided by the NAA. Under Alternative 4, there would be a $1.162 billion reduction in median NPV to -$937 million. Therefore, there would be long-term, major, adverse effects on economic viability of WVS power generation. There would also be negligible risk to local hydropower generation as Hills Creek and Cougar Dams would continue to be able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages resulting from weather events or fires.

Under Alternative 4, the additional storage would mean the reservoirs stay higher for more of the conservation season, resulting in minor to moderate benefits to reservoir recreation. This translates into slight increases in annual visitations, resulting in an approximate increase of $167,000 in annual economic benefits (a 0.82% increase) compared to the NAA. The regional economic impact from recreation effects is medium. The regional economic impacts are associated with a moderate reduction in regional output and the potential loss of 1.7 jobs in the South Santiam and McKenzie subbasins due to the drawdown at Green Peter and operations at Blue River Dam.

Despite the greatest spending on structural measures for ESA-listed species needs, Alternative 4 does not perform the best for meeting ESA focused Proposed Action objectives (objectives 4-6). Like Alternative 1, although Alternative 4 ranks moderately well for downstream survival (third) and three out of four UWR Chinook salmon populations would reach replacement, only two out of four UWR Chinook salmon populations would have high persistence (i.e., low risk of extinction). In contrast to Alternative 1, Alternative 4 does reduce risk to the McKenzie Core Legacy population and provides more habitat gains for bull trout compared to the NAA due to the inclusion of effective downstream passage at Cougar. Alternative 2A performs better than Alternative 4 for the replacement, persistence, and downstream survival and Alternatives 2B and 5 for the replacement.

Due to the scale of actions required under Alternative 4, this is the most expensive alternative. The high cost makes it unlikely this alternative would be acceptable to many stakeholders, agencies, and the public. In addition, Alternative 4 results in fewer benefits to ESA species than several less costly alternatives, including Alternatives 2A, 2B, and 5. Therefore, Alternative 4 was not identified as the Preferred Alternative.

## 5.17 Alternative 5. Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel) - Preferred Alternative

Alternative 5 was selected as USACE's Preferred Alternative. The Preferred Alternative improves fish passage through the WVS dams using a combination of modified operations and structural improvements, along with other measures to balance water management flexibility and meet ESA-listed fish obligations. A detailed description of Alternative 5 is provided in Section 2.4.11 of the PEIS.

Alternative 5 was developed after the formulation and analysis of all other action alternatives to allow for modeling results to inform formulation of the Preferred Alternative. Following the review of the alternatives' modeling results, Alternative 2B was initially selected as the Preferred Alternative. However, after engaging with cooperators USACE determined that the integrated temperature and habitat flow regime proposed in Alternative 2A should be refined to improve outcomes for ESA species. The Preferred Alternative, Alternative 5, is the same as Alternative 2B except that the integrated temperature and habitat flow regime has been replaced by the refined integrated temperature and habitat flow regime.

The Preferred Alternative contains both structural and operational measures to meet the Purpose and Need Statement and objectives developed for the PEIS Proposed Action as described in alternative 2B. The measures are intended to improve conditions for ESA-listed fish while providing flexibility for USACE to meet water demands for fish and wildlife, water supply, hydropower generation, and recreation in the WRB.

Following completion of ESA consultation with NMFS and USFWS, the Final PEIS will also explain components of the Preferred Alternative that are refined in response to ESA consultation, and responses to comments from the interested parties on the Draft PEIS. The Final PEIS will also revise the effects analysis in relation to refined components.

## 5.18 Effects of Alternative 5

The tradeoffs under Alternative 5 are the same as those discussed under Alternative 2B except that Alternative 5 would have a greater reduction by $6 million in NPV compared to Alternative 2B. In **Table ES-6**, a summary comparison of impacts, they are shown as identical but for the NPV reduction.

Under the refined integrated temperature and habitat flow regime, flows would be subject to change throughout the season based on realized hydrology and annual water management decisions. Additional water may be released from the projects to achieve temperature targets in the mainstem at Salem. These targets and minimum flow thresholds at Detroit/Big Cliff, Lookout Point/Dexter, and Foster would be modified according to the flow targets provided in Appendix A. Associated modeling parameters and results for each alternative that includes this measure are provided in Appendix B.

Like Alternative 2B, Alternative 5 is the fourth costliest alternative (exceeded by Alternatives 1, 2A, and 4) due to the numerous structural measures it includes. The estimated total annual cost for Alternative 2B is $62,291 million, $53 million greater than the NAA.

Under Alternative 5, there is an estimated decrease in total system-wide storage of 64,000 acre-feet from the NAA primarily due to the fish passage operation at Cougar. The small decrease in system-wide conservation storage would have a minor adverse effect to M&I water supply and irrigation users of the conservation storage.

Under Alternative 5, flow targets in the summer and fall would be met more frequently due to the additional accumulated stored water at WVS reservoirs other than Cougar and Green Peter. However, compared to NAA, the spring and early summer flows are similar or somewhat lower across the WVS. This is a result of the spring drawdown at Cougar Dam that occurs during the NAA refill period. Reduced storage at Cougar means that other WVS reservoirs, notably in the Middle Fork of the Willamette River subbasin, would be required to release additional water to meet mainstem Willamette River flow targets.

The drawdown of the Cougar Reservoir would effectively eliminate the use of stored water for water supply from Cougar. However, the Blue River Reservoir would fill more than under the NAA, partially offsetting the lost storage from Cougar Reservoir. Cougar Dam is also situated on the South Fork of the McKenzie River, and its flow is a small portion of the overall McKenzie River flow. The flow on the McKenzie River would be only slightly less in the driest years as compared to the NAA due to additional flow from Blue River. Therefore, Alternative 5 would have a negligible effect to live flow water rights in the McKenzie sub-basin. Due to the expected limited level of demand for stored water on the McKenzie River, Alternative 5, like 2B, would be expected to have only a minor adverse effect to M&I water supply and irrigation users in the McKenzie sub-basin.

The decrease in storage would contribute to an overall decrease in average annual hydropower generation by 18 aMW (roughly enough to power 14,334 households annually). Under Alternative 5, there would be a $939 million reduction in median NPV to -$714 million as compared to the NAA. Therefore, there would be long-term, major, adverse effects on economic viability of WVS power generation. In addition, the fish passage operation at Cougar Dam would result in infrequent, temporary major adverse effects on transmission services to Blue River. Deep fall and spring drawdowns would compromise Cougar Dam's ability to serve this community under temporary weather or fire related outage conditions. Generation at Hills Creek Dam would remain operable providing transmission services to Oakridge in emergency situations, like the NAA.

Alternatives 5 and 2B result in the smallest increases in annual visitations, resulting in an approximate increase of $12,000 in annual economic benefits (a 0.06% increase) compared to the NAA. Although this would be a negligible adverse effect on recreation across the WVS, the decrease in storage at Cougar Reservoir would result in major adverse effects to reservoir recreation at this location. However, as there are no jobs associated with recreation at Cougar Reservoir, the regional economic effects remain similar to those under Alternative 2A. The regional economic impact from recreation effects is medium. The regional economic impacts are associated with the potential loss of 1.7 jobs in the South Santiam Basin due to the drawdown at Green Peter and a moderate reduction in regional output.

Like Alternative 2B, Alternative 5 effectively meets the ESA focused Proposed Action objectives (objectives 4-6), surpassed only by Alternative 2A. Alternatives 5 and 2B rank fourth for downstream survival with all UWR Chinook salmon populations reaching replacement. Alternative 5 also reduces risk to the McKenzie Core Legacy population and provides more habitat gains for bull trout compared to the NAA due to the inclusion of effective downstream passage at Cougar.

In contrast to Alternative 2A, Alternatives 5 and 2B result in only three of the four UWR Chinook salmon populations with high persistence. This is the biggest difference in how Alternatives 5 and 2B perform for the ESA objectives compared to Alternative 2A, a result of the downstream fish passage measure proposed at Cougar Dam. Alternative 2A proposes a FSS and Alternatives 5 and 2B propose a deep drawdown to pass fish through the diversion tunnel. The difference in the number of populations with high persistence is because the ESA models assume increases in downstream survival with a structure at Cougar Dam than through a deep drawdown operation. However, there is higher confidence that the diversion tunnel operation at Cougar will be successful making the likelihood of meeting the PEIS ESA objective more certain to occur thus it was selected.

# 6 SUMMARY COMPARISON OF EFFECTS OF ALTERNATIVES TABLE

Using the evaluation criteria described in Chapter 5 of the PEIS, **Table ES-6** summarizes and compares the most important effects of the action alternatives against the No Action Alternative baseline.

The effects on those resources listed in Section 4.4 of this Executive Summary but not shown in **Table ES-6** are generally of lower magnitude, typically ranging from negligible to minor and sometimes moderate. These effects are discussed in detail in the appropriate resource sections of Chapter 3 of the PEIS.

**Table ES- 6. Alternatives Criteria Comparison to NAA.**

| Criteria | Metric | No Action Alternative | Alt 1 | Alt 2A | Alt 2B | Alt 3A | Alt 3B | Alt 4 | Alt 5 |
|---|---|---|---|---|---|---|---|---|---|
| Effectiveness meeting Objective 1 | Change in Conservation Storage from NAA (acre-feet) | 1,329,000 | +168,000 | +122,000 | -64,000 | -590,000 | -669,000 | +122,000 | -98,536 |
| Effectiveness meeting Objective 1 | Impact to flows compared to NAA. | – | Low | Low | Medium | High | High | Low | Medium |
| Effectiveness meeting Objective 3 | Change in NPV from NAA ($ millions) | $225 | -$1,159 | -$863 | -$933 | -$853 | -$829 | -$1,162 | -$939 |
| Effectiveness meeting Objectives 4-6 | Chinook Populations reaching replacement | 2 of 4 Chinook populations reach replacement. | +1 population | +2 populations | +2 populations | +2 populations | +2 populations | +1 population | +2 populations |
| Effectiveness meeting Objectives 4-6 | Chinook Populations' persistence | 1 of 4 Chinook populations with high persistence. | +1 population | +2 population | +1 population | +0 populations | +1 population | +1 population | +1 population |
| Effectiveness meeting Objectives 4-6 | Legacy Chinook Population risk | Legacy Chinook population is at risk | No change in risk | Risk reduced | Risk reduced | No change in risk | No change in risk | Risk reduced | Risk reduced |

| Criteria | Metric | No Action Alternative | Alt 1 | Alt 2A | Alt 2B | Alt 3A | Alt 3B | Alt 4 | Alt 5 |
|---|---|---|---|---|---|---|---|---|---|
| Effectiveness meeting Objectives 4-6 | Downstream survival relative rank: 1=best, 7=worst | 7 | 1 | 2 | 4 | 5 | 6 | 3 | 4 |
| Effectiveness meeting Objectives 4-6 | Bull trout habitat gains | No habitat gains for bull trout. | Least habitat gains for bull trout. | Habitat gains for bull trout. | Habitat gains for bull trout. | Habitat gains for bull trout. | No habitat gains for bull trout. | Habitat gains for bull trout. | Habitat gains for bull trout. |
| Estimated Total Annual Cost | Millions of US $ | $9 | +$95 | +$58 | +$53 | +$17 | +$21 | +$104 | +$53 |
| Economic impact to recreation | Change in Average Annual NED Recreation Benefits (total for all reservoirs in millions of dollars) from NAA | $20.45 | +$0.31 | +$0.17 | +$0.02 | -$0.76 | -$1.27 | +$0.17 | +$0.02 |
| Acceptability Criteria: Economic | Impact to regional economic development from Recreation Effects | – | Low | Medium | Medium | High | High | Medium | Medium |

[1]Note: No color indicates no, negligible, or minor effects. Blue indicates a positive/beneficial effect, yellow indicates a moderate negative/adverse effect, and orange indicates a high negative/advise effect.

# 7 CONCLUSION

This PEIS for the WVS evaluates both the beneficial and adverse effects on the human environment of various ways of managing the WVS in pursuit of its authorized purposes, while at the same time attempting to enhance fish passage and habitat conditions for Upper Willamette fish species, particularly UWR Chinook salmon, UWR steelhead, and bull trout.

In keeping with established procedures of the NEPA, the WVS PEIS identifies the purpose and need of the proposed action, develops an array of reasonable alternatives, describes the affected environment for each resource assessed, and analyzes direct, indirect, and cumulative effects of pursuing the no action and action alternatives on those resources. The PEIS presents the analysis of the No Action Alternative and the seven action alternatives – 1, 2A, 2B, 3A, 3B, 4, and 5. Each of these alternatives has been evaluated for its merits and deficiencies in the WVS PEIS.

USACE identifies Alternative 5 as its Preferred Alternative. Alternative 5, a composite, was formulated after the other alternatives were evaluated in coordination, consultation, or collaboration with key stakeholders. The Preferred Alternative improves fish passage through the WVS dams using a combination of modified operations and structural improvements, along with other measures to balance water management flexibility and meet ESA-listed fish obligations. At this juncture, USACE believes Alternative 5 is the most effective at achieving the objectives of the WVS PEIS.

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| | |
|---|---|
| °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.D. | Anno Domini |
| ACDP | Air Contaminant Discharge Permit |
| ACM | Asbestos-containing Materials |
| ACS | American Community Survey |
| AEP | Annual Exceedance Probability |
| AFF | Adult Fish Facilities |
| AI | Agricultural irrigation |
| ALBO | Mainstem Willamette River at Albany |
| aMW | Average Megawatt |
| AR | Administrative Record |
| ARPA | Archaeological Resources Protection Act |
| AWS | Auxiliary Water Supply |
| B.P. | years Before the Present |
| BA | Biological Assessment |
| BCL | Big Cliff |
| BCLO | Downstream of Big Cliff and Detroit |
| BEA | Bureau of Economic Analysis |
| BES | Bulk Electric Power System |
| BiOp | Biological Opinion |
| BLM | Bureau of Land Management |
| BLS | Bureau of Labor Statistics |
| BLU | Blue River |
| BMP | Best Management Practices |
| BOR | Bureau of Reclamation |
| BPA | Bonneville Power Administration |
| CAA | Clean Air Act |
| CCS | Cross Cascades South |
| CEAA | Cumulative effects analysis area |
| CEQ | Council on Environmental Quality |
| CERCLA | Comprehensive Environmental Response and Liability Act |
| CESQG | Conditionally Exempt Small Quantity Generator |
| CFR | Code of Federal Regulations |
| cfs | cubic feet per second |
| CGR | Cougar |
| CGRO | Downstream of Cougar |
| $CH_3Hg$ | Methylmercury |
| CO | Carbon Monoxide |
| CO2 | Carbon Dioxide |
| COP | Configuration and Operations Plan |
| CRBG | Columbia River Basalt Group |
| CRR | Cohort Replacement Rate |
| CS | Conservation Strategy |
| CSZ | Cascadia Subduction Zone |
| CTCLUSI | Confederated Tribes of the Coos, Lower Umpqua and Siuslaw |
| CTG | Cottage Grove |
| CTUIR | Confederated Tribes of the Umatilla Indian Reservation |
| CWA | Clean Water Act |
| CWY | Critical Water Year |
| dBA | A-weighted decibel |
| DET | Detroit |
| DEX | Dexter |
| DEXO | Downstream of Dexter |
| DHHS | Department of Health and Human Services |
| DLCD | Oregon Department of Land Conservation and Development |
| DO | Dissolved Oxygen |
| DOE | United States Department of Energy |
| DOR | Dorena |
| DPS | Distinct population segment |
| DT | Diversion tunnel |
| E3 | Energy and Environmental Economics, Inc. |
| EA | Environmental Assessment |
| EDG | Emergency diesel generators |
| EDT | Ecological Diagnosis Treatment |
| E-flow | Environmental Flow |
| EGM | Economic Guidance Memoranda |
| EIS | Environmental Impact Statement |
| EJ | Environmental Justice |
| EM | Engineer Manual |
| EO | Executive Order |
| EPA | United States Environmental Protection Agency |

| | |
|---|---|
| EPCRA | Emergency planning and community right to know act |
| EQ | Environmental Quality |
| ER | Engineering Regulation |
| ESA | Endangered Species Act |
| ESU | Evolutionarily Significant Unit |
| EWEB | Eugene Water Electric Board |
| F&W | Fish and Wildlife |
| FBW | Fish Benefits Workbook |
| FCA | Flood Control Act |
| FCR | Fall Creek |
| FCRPS | Federal Columbia River Power System |
| FEMA | Federal Emergency Management Agency |
| FERC | Federal Energy Regulatory Commission |
| FIFRA | Federal Insecticide, Fungicide, and Rodenticide Act |
| FMWQT | Flow Management and Water Quality Team |
| FOS | Foster |
| FR | Federal Register |
| FRM | Flood risk management |
| FRN | Fern Ridge |
| FSC | Floating Surface Collector |
| FSS | Floating Screen Structure |
| ft | feet |
| FWWS | Forebay Warm Water Supply |
| FY | Fiscal Year |
| GBD | Gas Bubble Disease |
| GDP | Gross Domestic Product |
| GENESYS | GENeration Evaluation SYStem |
| GHGs | Greenhouse Gases |
| GIS | Geographic Information Systems |
| GLO | General Land Office |
| GPR | Green Peter |
| H&H | Hydrology and Hydraulics |
| $H_2S$ | Hydrogen Sulfide |
| HABHRCA | Harmful Algal Bloom and Hypoxia Research and Control Amendments Act |
| HABs | Harmful algal blooms |
| HAPs | Hazardous air pollutants |
| HAZWOPER | Hazardous Waste Operations and Emergency Response |
| HB | House Bill |
| HCR | Hills Creek |
| HCRO | Downstream of Hills Creek |
| HD | House Document |
| HEC-RAS | Hydrologic Engineering Center's River Analysis System |
| HEC-ResSim | Hydrologic Engineering Center Reservoir Simulation |
| Hg | Mercury |
| HGMP | Hatchery Genetic Management Plan |
| HPRCSITs | Historic Properties of Religious and Cultural Significance to Indian Tribes |
| HSRG | Hatchery Science Review Group |
| HTRW | Hazardous, Toxic, and Radioactive Waste |
| HYDSIM | Hydropower Simulation Model |
| I-5 | Interstate 5 |
| IOUs | Investor-owned Utilities |
| IPA | Integrated Passage Assessment |
| IPM | Integrated Pest Management |
| IRRM | Interim Risk Reduction Measures |
| Kaf | Thousand acre-feet |
| $Km^2$ | Kilometers squared |
| kV | Kilovolt |
| LBP | Lead-based Paint |
| LCM | Life Cycle Model |
| LCOG | Levelized Cost of Generation |
| LE | Listed as Endangered |
| LEV | Low Emission Vehicle |
| LOLP | Loss of Load Possibility |
| LOP | Lookout Point |
| LRAPA | Lane Regional Air Protection Network |
| LRO | Lower Regulating Outlets |
| LUB | Lacustrine unconsolidated bottom |
| M&I | Municipal and Industrial |
| Maf | Million acre-feet |
| MCLs | Maximum contaminant levels |
| MFR | Memorandum for the Record |
| mg/kg | Milligrams per Kilogram |
| MMC | Methyl Mercury |
| MOC | Memorandum of Coordination |

| | |
|---|---|
| MOU | Memorandum of Understanding |
| mph | Miles per hour |
| MPSFs | Minimum Perennial Streamflows |
| MSE | Management Strategy Evaluation |
| MSL | Mean Sea Level |
| MW | Megawatt |
| Mw | Magnitude |
| MWh | Megawatt hour |
| NAA | No Action Alternative |
| NAAQS | National Ambient Air Quality Standards |
| NAGPRA | Native American Graves Protection and Repatriation Act |
| NAVD88 | North American Vertical Datum of 1988 |
| NED | National Economic Development |
| NEPA | National Environmental Policy Act |
| ng/L | nanograms per Liter |
| NGO | Non-governmental Organization |
| NGVD | National Geodetic Vertical Datum |
| NHPA | National Historic Preservation Act |
| NLCD | National Land Cover Database |
| NMFS | National Marine Fisheries Service |
| $NO_2$ | Nitrogen Dioxide |
| NOAA | National Oceanic and Atmospheric Administration |
| NOI | Notice of Intent |
| NOR | Natural-origin Salmon |
| NPDES | National Pollutant Discharge Elimination System |
| NPDWR | National Primary Drinking Water Regulations |
| NPL | National Priorities List |
| NPV | Net Present Value |
| NRCS | Natural Resources Conservation Service |
| NRHP | National Register of Historic Places |
| NRI | National Resources Inventory |
| NRRS | National Recreation Reservation System |
| NSDWR | National Secondary Drinking Water Regulations |
| NSR | New Source Review |
| NTOM | Near Term operations measure |
| NWFSC | Northwest Fisheries Science Center |
| NWI | National Wetlands Inventory |
| NWPP | Northwest Power Pool Corporation |
| NWRFC | Northwest River Forecast Center |
| NWS | National Weather Service |
| O&C | Oregon and California Railroad |
| O&M | Operations and Maintenance |
| O3 | Ozone |
| OAR | Oregon Administrative Rules |
| OCS | Oregon Conservation Species |
| ODA | Oregon Department of Agriculture |
| ODEQ | Oregon Department of Environmental Quality |
| ODFW | Oregon Department of Fish and Wildlife |
| ODLCD | Oregon's 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 |
| OHA | Oregon Health Authority |
| OHWM | Ordinary High Water Mark |
| OMBIL | Operations and Maintenance Business Information Link |
| OMRR&R | Operation, Maintenance, Repair, Replacement, And Rehabilitation |
| OPRD | Oregon Parks and Recreation Department |
| ORBIC | Oregon Biodiversity Information Center |
| ORS | Oregon Revised Statues |
| OSE | Other Social Effects |
| OSHA | Occupational Safety and Health Administration |
| OWRD | Oregon Water Resources Department |
| OWS | Oily Water Separator |
| PAB | Palustrine aquatic bed |
| Pb | Lead |
| PCBs | Polychlorinated Biphenyls (PCBs) |
| PCPI | Per capita personal income |
| PEIS | Programmatic Environmental Impact Statement |

| | |
|---|---|
| PEM | Palustrine emergent |
| PFMC | Pacific Fishery Management Council |
| PFO | Palustrine forested |
| pH | Potential of Hydrogen |
| pHOS | Proportion of hatchery-origin spawners |
| PIT | Passive Integrated Transponders |
| PM | Particulate Matter |
| pNOB | Proportion of natural-origin brood |
| PNW | Pacific Northwest |
| POS | Period of Significance |
| pp. | Pages |
| ppb | parts per billion |
| PPE | Personal protective equipment |
| ppm | parts per million |
| PSD | Prevention of Significant Deterioration |
| PSM | Pre-spawn Mortality |
| PSS | Palustrine scrub-shrub |
| PUB | Palustrine unconsolidated bottom |
| PUDs | Public Utility Districts |
| QET | Quasi-extinction risk |
| R&D | Research and Design |
| R/S | Recruits/Spawner |
| RA | Resource Agency |
| RCRA | Resource Conservation and Recovery Act |
| RECONS | Regional Economic System |
| RED | Regional Economic Development |
| RFC | Regional Forecast Center |
| RFFA | Reasonably foreseeable future actions |
| RICE | Reciprocating Internal Combustion Engines |
| RM | River Mile |
| RM&E | Research, Monitoring, and Evaluation |
| RMJOC | River Management Joint Operating Committee |
| RO | Regulating Outlet |
| ROC | Region of Comparison |
| ROD | Record of Decision |
| ROI | Region of Influence |
| RPA | Reasonable and Prudent Alternative |
| RUB | Riverine unconsolidated bottom |
| RUS | Riverine unconsolidated shore |
| SAR | Smolt-to-adult-return rates |
| SC | Sensitive Critical |
| SCORP | Statewide Comprehensive Outdoor Recreation Plan |
| SDSs | Safety data sheets |
| SDWA | Safe Drinking Water Act |
| SEF | Sediment Evaluation Framework |
| SHPO | State Historic Preservation Office |
| SIP | State Implementation Plan |
| SLMO | Mainstem Willamette River at Salem |
| $SO_2$ | Sulfur Dioxide |
| SOA | South of Allston |
| SOC | Species of Concern |
| SPCC | Spill Prevention, Control, and Countermeasure |
| SRKW | Southern Resident Killer Whale |
| SRP | Sustainable Rivers Program |
| SSFO | Downstream of Foster and Green Peter |
| SWCD | Santiam Water Control District |
| SWS | Selective Withdrawal Structure |
| SWTR | Surface Water Treatment Rule |
| SYSTDG | System Total Dissolved Gas |
| T&E | Threatened and Endangered |
| TCP | Traditional Cultural Properties |
| TDG | Total Dissolved Gas |
| THg | Total Mercury |
| TLCP | Toxicity Characteristic Leachate |
| TMDL | Total Maximum Daily Load |
| TNC | The Nature Conservancy |
| TRI | Toxics Release Inventory |
| TSS | Total suspended solids |
| U.S. | United States |
| UBC | University of British Columbia |
| UGB | Urban Growth Boundary |
| URO | Upper Regulating Outlets |
| USACE | U.S. Army Corps of Engineers |
| USC | United States Code |
| USCB | U.S. Census Bureau |
| USDA | U.S. Department of Agriculture |
| USDOT | U.S. Department of Transportation |
| USFS | United States Forest Service |
| USFWS | U.S. Fish and Wildlife Service |

| | |
|---|---|
| USGS | United States Geological Survey |
| UST | Underground storage tank |
| UWR | Upper Willamette River |
| VERS | Visitation Estimation & Reporting System |
| VOCs | Volatile organic compounds |
| VRI | Visual Resource Inventory |
| VRM | Visual Resource Management |
| VSP | Viable Salmonid Population |
| WAIN | Willamette Aquatic Invasives Network |
| WATER | Willamette Action Team for Ecosystem Restoration |
| WBR | Willamette Basin Review |
| WECC | Western Electricity Coordinating Council |
| WFOP | Willamette Fish Operations Plan |
| WFPOM | Willamette Fish Passage Operations & Maintenance |
| WHO | World Health Organization |
| WHPP | Wellhead Protection Program |
| WLCTRT | Willamette/Lower Columbia Technical Recovery Team |
| WNF | Willamette National Forest |
| WRB | Willamette River Basin |
| WRBBPP | Willamette River Basin Bank Protection Program |
| WRDA | Water Resources Development Act |
| WSE | Water surface elevation |
| WTC | Water Temperature Control |
| WTP | Willingness to Pay |
| WVB | Willamette Valley Basin |
| WVS | Willamette Valley System |
| Wy | Water year |

# CHAPTER 1 - INTRODUCTION

The Willamette Valley System, referred to as the WVS or “the project”, is a combination of 13 *U.S. Army Corps of Engineers-managed* multipurpose dams, reservoirs, and revetments collectively referred to as “projects” or individually as “a project.” Additionally, the WVS includes U.S. Army Corps of Engineers (USACE) riverbank protection projects, fish passage facilities, adult fish facilities, and hatchery programs in the Willamette River Basin (WRB) in Oregon. These projects, facilities, and programs contain physical and operational “components.”

The various purposes of the WVS were authorized by Congress in the Flood Control Acts (FCA) between 1938 and 1962, the Water Supply Act of 1958, and the Water Resources Development Act of 1986. In these acts Congress designated the purpose for each project, which can include a combination of the following:

- flood control (more commonly referred to today as flood risk management (FRM))
- hydropower
- fish and wildlife
- recreation
- navigation
- irrigation (referred to as agricultural irrigation (AI))
- municipal and industrial (M&I) water supply
- water quality

The Portland District, USACE, operates and maintains the WVS to meet the purposes of the projects as authorized by Congress. The system-wide environmental effects of these ongoing operations and maintenance (O&M) activities were last analyzed in an Environmental Impact Statement (EIS) in 1980. Since that time conditions in the WRB have changed and new information has become available. Biological Opinions (BiOps) have also been issued pursuant to compliance with the Endangered Species Act (ESA) of 1973, as amended, seeking to lessen the effects of the O&M of the WVS on threatened and endangered (T&E) species.

**Table 1.1-1. Summary of Terminology in the PEIS**

| Term | Definition |
|---|---|
| Willamette Valley System (WVS) | The 13 USACE-managed dams, reservoirs, and revetments in the analysis area. |
| Project(s) | The overall project is the WVS. Individual projects are also identified within the WVS. |

| Term | Definition |
|---|---|
| Components | Current or ongoing structural elements of projects, facilities, and programs within the WVS. |
| Actions | Proposed or ongoing measures incorporated under each alternative to meet the purpose and need for the proposed action. Is synonymous with "measures." |
| Measures | Proposed components or actions that would be taken under each alternative to meet the purpose and need for the proposed action. Is synonymous with "actions." |
| Analysis Area | The area of primary study for resources described as the affected environment in Chapter 3.0. The analysis area in this PEIS is the Willamette River Basin (WRB). |

**Chapter Organization**

Chapter 1 is organized as follows:

- **1.1 Regulatory Background** - Describes the history of environmental compliance for operations and maintenance of the WVS and explains the regulatory framework for the WVS draft Programmatic Environmental Impact Statement (PEIS).
- **1.2 Geographic and Temporal Scope** - Identifies the spatial bounds and time frame of the study.
- **1.3 Proposed Action and Purpose and Need** - Defines the NEPA purpose of and need for the proposed action.
- **1.4 Cooperating Agencies** - Identifies cooperating agencies and describes their involvement in preparation of the draft PEIS.
- **1.5 USACE-managed Dams and Reservoirs in the Willamette Valley System** - Describes the setting, components, and operations of the WVS.
- **1.6 USACE Programs in the Willamette River Basin** - Describes the Willamette River Basin Bank Protection Program; the Willamette Hatchery Mitigation Program; adult fish facilities; and research, monitoring, and evaluation activities.
- **1.7 Authorized Purposes** - Details the authorized purposes for the WVS.
- **1.8 System Operation and Annual Operational Planning -** Describes the system operations planning used for meeting several objectives for current operation of the dams and reservoirs.
- **1.9 Ongoing USACE Planning and Environmental reviews in the Region** – Describes ongoing and related projects by the USACE that are planned or ongoing in the region.

## 1.1 REGULATORY BACKGROUND

The most recent NEPA evaluation for O&M of the WVS was an EIS completed in 1980. Since that time, project-specific NEPA evaluations have been conducted, but none for O&M of the system as a whole. Over the years, conditions in the WRB have changed primarily with respect to continued population growth and associated development, new information relevant to effects on threatened and endangered species, and operations have been modified and structural improvements implemented for fish passage and temperature control. These changes combined with the extent of time since the last WVS O&M NEPA evaluation necessitated the preparation of a new EIS.

USACE determined that a programmatic approach to NEPA evaluation would be most appropriate because the WVS is made up of many physical and operational components. Additionally, O&M can be implemented in different ways at different times on different components. The programmatic approach is further described below in Section 1.1.1.1. In addition to NEPA and ESA compliance, consideration of treaties, applicable laws, regulations, and executive orders is also required for this project. A detailed description of these compliances can be found in Chapter 7. For context, NEPA and the ESA are discussed in further detail below.

### 1.1.1 The National Environmental Policy Act

NEPA was established to ensure that the federal government appropriately considers the potential effects on the human environment of major federal actions. USACE is proposing updates to its O&M of the WVS and in doing so must comply with NEPA, the Council on Environmental Quality's NEPA-implementing regulations (40 CFR Part 1500-1508)[1], and the USACE NEPA-implementing regulations (33 CFR Part 230). As a general overview, NEPA requires responsible agencies to do the following:

- Identify the proposed action.
- Identify the purpose of and need for the proposed action.
- Identify all reasonable alternatives to meet that need as well as the alternative of taking no action.
- Identify, evaluate, and compare the effects on the human environment that could arise from each of the alternatives, as well as the No Action Alternative (NAA).
- Publish the above information in an environmental document for review by the public and other agencies.
- Consider public and agency comments before making its decision on the proposed action.

[1] CEQ is in the process of revising NEPA regulations. Because the regulations were not finalized when this PEIS was initiated, USACE noticed the public that the PEIS complies with the 1978 CEQ NEPA implementing regulations as amended. Additionally, the PEIS follows the most current CEQ guidance on use of programmatic NEPA reviews, December 18, 2014.

The proposed action under review in this PEIS and the purpose of and need for the proposed action are discussed in Section 1.3.

#### *1.1.1.1 Programmatic Review under the National Environmental Policy Act*

The NEPA compliance process can be conducted for a specific project or for an entire program as defined by CEQ guidance.

> Programmatic NEPA reviews address the general environmental issues relating to broad decisions, such as those establishing policies, plans, programs, or suite of projects, and can effectively frame the scope of subsequent site- and project-specific Federal actions. A well-crafted programmatic NEPA review provides the basis for decisions to approve such broad or high-level decisions such as identifying geographically bounded areas within which future proposed activities can be taken or identifying broad mitigation and conservation measures that can be applied to subsequent tiered reviews…
>
> One advantage of preparing a programmatic NEPA review for repetitive agency activities is that the programmatic NEPA review can provide a starting point for analyzing direct, indirect, and cumulative impacts. Using programmatic NEPA reviews allows an agency to subsequently tier to this analysis, and analyze narrower, site- or proposal-specific issues. This avoids repetitive broad level analyses in subsequent tiered NEPA reviews and provides a more comprehensive picture of the consequences of multiple proposed actions (CEQ, 2014).

Operation and maintenance of the WVS fits this guidance. The system consists of multiple projects, components, and activities within a shared geography, central Oregon's WRB, and are managed individually and in concert dynamically over time to achieve the authorized purposes of the projects and to avoid jeopardizing ESA-listed species.

The multiple activities being considered are various physical and operational components for continued O&M of the system and various formulations of operational changes, modifications of existing structures, and construction of new structures.

The overall operation and management of the WVS can, therefore, be conceptualized and evaluated as a program in this PEIS. Subsequent, site-specific O&M and ESA-compliance actions can then be tiered under, or incorporate by reference in, the PEIS as they arise.

The PEIS process is the same as other NEPA EIS review processes. As with site-specific NEPA reviews, programmatic reviews analyze potential effects under a range of reasonable alternatives but at the broader scale. The PEIS is made available for public comment. Following consideration of these comments and any new information identified from draft PEIS issuance, the lead agency prepares its decision on the alternative, or combination of alternative components, to implement. This decision is documented in a Record of Decision, or ROD.

Preparation of a PEIS will support efficient future NEPA compliance documentation for individual USACE projects by reducing repetitive analyses. A programmatic approach addresses the general environmental issues relating to broad decisions establishing WVS policies, plans, programs, and suite of projects, and effectively frames the scope of subsequent site- and project-specific USACE actions that can be applied to subsequent tiered reviews.

The WVS PEIS process is further described in Section 7.2.

### 1.1.2 The Endangered Species Act

The ESA of 1973 (16 United States Code [USC] § 1531 et seq.), and its subsequent amendments, was established for the conservation of threatened and endangered species and the habitat they require for survival. The purpose of the law is to both protect and recover imperiled species and the habitats or ecosystems upon which the species depend.

Species that are in danger of extinction may be listed by the National Marine Fisheries Service (NMFS) and/or the United States Fish and Wildlife Service (USFWS) (together referred to as the Services) under the ESA as a threatened or endangered species, thereby providing certain protections to the species. The ESA also authorizes the Services to designate certain areas as "critical habitat" for the survival of a listed species or sub-species (Critical habitat is defined in the ESA in Section 3(5)(A)(B)(C)).

In addition to the above, Section 7(a)(2) of the ESA states that federal agencies shall, in consultation with the Services, ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. In fulfilling the requirements of Section 7(a)(2), each agency must use the best scientific and commercial data available.

The Services listed species under the ESA after USACE finalized its 1980 WVS EIS. Bull trout were listed as threatened in 1998, and the Upper Willamette River (UWR) spring Chinook salmon and UWR winter steelhead were listed as threatened in 1999. The Oregon chub was de-listed by the USFWS in 2015, meaning that it no longer falls under the protection of the ESA.

Additionally, several Evolutionarily Significant Units (ESUs) are listed by NMFS for UWR spring Chinook salmon and UWR winter steelhead (NWFSC, 2015). An ESU is a Pacific salmon population or group of populations that is substantially reproductively isolated from other conspecific2 populations and that represents an important component of the evolutionary legacy of the species.

The two listed ESUs present an important aspect of intraspecific biodiversity (i.e., genetic diversity within a given species) and an important component in the evolutionary legacy of the two listed salmonid species within the WRB.

[2] "Conspecific" is defined as belonging to the same species.

USACE, the Bureau of Reclamation (BOR), and the Bonneville Power Administration (BPA), consulted with the Services after these species were listed. Subsequently, NMFS issued the *ESA Section 7(a)(2) Consultation, Biological Opinion (BiOp) and Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation on the Willamette River Basin Flood Control Project* (2008 NMFS BiOp) on July 11, 2008 (NMFS, 2008).

The 2008 NMFS BiOp evaluated the effect of continued O&M of the WVS on UWR spring Chinook salmon and UWR winter steelhead. NMFS concluded that the action proposed during consultation would not avoid a finding of jeopardy or adverse modification of designated critical habitat for UWR spring Chinook salmon and UWR winter steelhead. The BiOp stipulated a Reasonable and Prudent Alternative (RPA), which was a suite of actions expected to avoid the likelihood of jeopardizing the continued existence of listed species or destroying or adversely modifying designated critical habitat.

USFWS published the BiOp for the *Continued Operation and Maintenance of the Willamette River Basin Project and Effect to Oregon Chub, Bull Trout, and Bull Trout Critical Habitat Designated Under the Endangered Species Act* (2008 USFWS BiOp) in 2008, outlining the effects of the WVS on Oregon chub (delisted in 2015), bull trout, and bull trout critical habitat (USFWS, 2008). USFWS reached a no jeopardy determination in its 2008 BiOp provided USACE, BOR, and BPA implemented the 2008 NMFS BiOp RPA and considered the effects on Oregon chub and bull trout when applying measures covered in the RPA.

Since 2008, USACE has been implementing the RPA provided in the 2008 NMFS BiOp. Over time, this has changed O&M of the WVS sufficiently to necessitate additional analyses under NEPA with a PEIS. USACE has also re-initiated formal consultation under Section 7 of the ESA for the continued O&M of the WVS and to implement operations and construct projects to address fish passage and water quality. This NEPA process will inform the ESA Section 7 consultation process. The WVS ESA compliance status is further described in Section 7.4.

## 1.2 GEOGRAPHIC AND TEMPORAL SCOPE

### 1.2.1 Geographic Scope

The area of analysis, or geographic scope, for assessing the direct, indirect, and cumulative effects of the proposed action is generally the WRB. More specifically, the proposed action takes place within the six sub-basins that contain the WVS and the mainstem Willamette River into which these sub-basins feed.

<u>WVS Sub-basins</u>

Middle Fork Willamette

Coast Fork Willamette

McKenzie River

Long Tom

South Santiam

North Santiam

#### *1.2.1.1 The Willamette River Basin*

The Willamette River is a major tributary of the Columbia River, which is the largest river in the Pacific Northwest and one of the largest in North America. The Willamette River lies entirely within the state of Oregon and is the 13th largest river in the United States (U.S.) by annual flow volume.

A river basin, also referred to as a watershed, is an area of land that that drains to an outlet to another water body. Sub-basins in the watershed are drained by tributaries to the main river. The WRB is approximately 11,500-square-miles and is drained by the Willamette River, which flows north through a fertile valley in western Oregon (USACE, 2019a). The WRB is located entirely within the State of Oregon, beginning south of Cottage Grove and extending approximately 187 miles to the north where it flows into the Columbia River (Figure 1.2-1).

The Willamette River is the 13th largest river in the conterminous U.S. in terms of streamflow and produces more runoff per unit area than any of the 12 larger rivers (EPA, 2013). The WRB averages 75 miles in width and encompasses approximately 12 percent of the total area of the state (USACE, 2019a).

The WRB is bound by three mountain ranges: the Cascade Range to the east, the Coast Range to the west, and the Calapooya Mountains to the south. Maximum elevations exceed 10,000 feet in the Cascade Range, 4,000 feet in the Coast Range, and 6,000 feet in the Calapooya Mountains.

Major Cascade Range tributaries include the Santiam, McKenzie, Middle Fork of the Willamette, Molalla, and Clackamas Rivers. The Willamette River is also fed by major tributaries from the Coast Range, including the Long Tom, Marys, Luckiamute, Yamhill, and Tualatin Rivers. At the south end of the basin, the Coast Fork of the Willamette River emerges from the Calapooya Mountains and joins the mainstem Willamette River near the City of Springfield (USACE, 2019a).

Although there are six sub-basins within the WVS, the WRB encompasses 12 sub-basins, or smaller basins within the larger WRB. These are the Lower Willamette, Tualatin, Molalla-Pudding, Yamhill, Clackamas, South Santiam, North Santiam, Middle Willamette, McKenzie, Coast Fork Willamette, Middle Fork Willamette, and Upper Willamette sub-basins. As discussed above, six of these sub-basins contain dams; these sub-basins encompass the WVS.

The Willamette Valley has been inhabited since recorded time and continues to be the home of members of several tribes. When non-native settlers arrived in the Willamette Valley in the mid-1800s, the valley was broad with a shallow braided channel across a wide floodplain that was flooded annually in winter. As homesteaders developed agricultural and suburban communities in the Willamette Valley they encountered frequent floods, including the devastating 1861 event that flooded the Portland business district for weeks. This led Congress to authorize USACE to construct, operate, and maintain the WVS for flood control purposes with authorizations beginning in 1938.

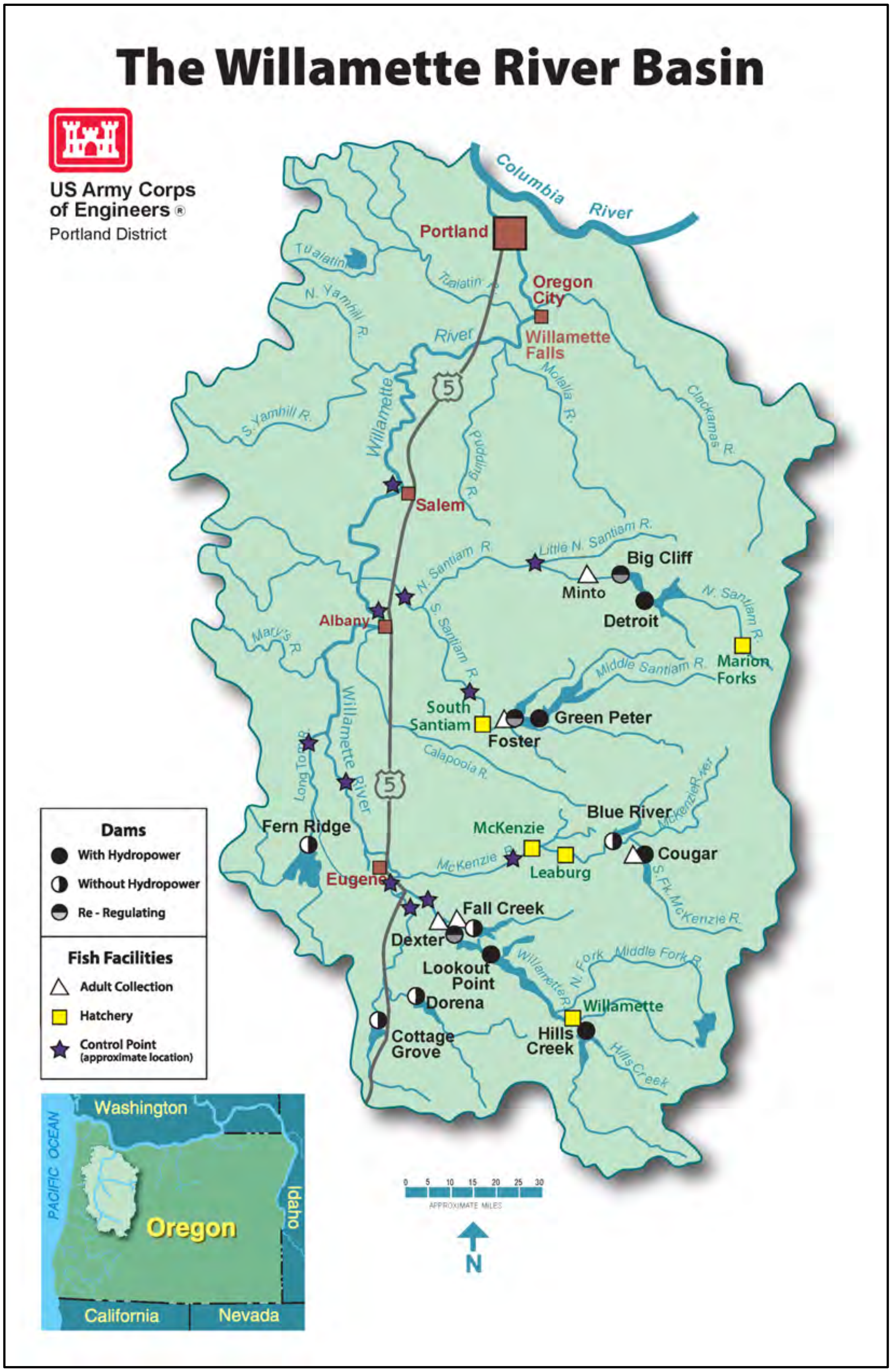


**Figure 1.2-1. USACE-managed Facilities in the Willamette River Basin**

#### *1.2.1.2 Non-USACE-managed Dams and Structures in the Willamette River Basin*

In addition to the 13 USACE-managed dams in the WRB, there are 247 other dams dispersed throughout the WRB managed by other entities (USACE, 2020h). Most of these non-USACE-managed dams are more than 50 years old and are small to medium-sized facilities; there are few large dams and reservoirs in the WRB. Most dams are below 30 feet in height, and only a few reservoirs have water storage capacity that exceeds 1,000 acre-feet. Most have under 500 acre-feet of storage capacity, and many less than 100 acre-feet. More than 90 percent of these 247 dams are earth-fill.

Most of the dams are privately owned; some are owned by municipalities, public utilities, and the USFWS, BOR, or U.S. Forest Service (USFS). Most purposes are for irrigation, recreation, fish- and wildlife-related planning, and to a smaller extent, hydroelectricity, and municipal and industrial water supply.

Of these 247 non-USACE-managed dams in the WRB in its entirety, only 38 dams are in WRB sub-basins containing WVS dams/reservoirs. Additionally, approximately 105 bank protection structures originally built by USACE along WRB riverbanks are at present maintained by local, non-USACE sponsors in the WRB (other structures continue to be maintained by USACE; Section 1.6.1). These structures include riprap revetments, steel pile bulkheads, timber bulkheads, drift barriers, and earthen embankments to "armor" riverbanks and protect them from erosive floodwaters.

Combined with USACE-managed dams and reservoirs, these widely dispersed structures support the growing human population and economic activity in the WRB by providing water (both agricultural irrigation and municipal/industrial supply), generating electricity, and recreational opportunities. However, they also affect the WRB's hydrology and salmon runs by obstructing upstream and downstream migration and altering spawning and rearing habitat.

### 1.2.2 Temporal Scale

The temporal scope of analysis for the PEIS is 30 years from the signing of the Record of Decision (ROD). USACE considered several factors when defining the temporal scale, such as the ability to project data with confidence for the resources that would be affected, the time frame for implementation for the actions considered, and similar NEPA documents published by USACE.

## 1.3 PROPOSED ACTION AND PURPOSE AND NEED

The proposed action is continued operation and maintenance of the WVS for specific, authorized purposes and in compliance with the ESA and all other applicable treaties, laws, and regulations.

The purpose of and need for the proposed action is to ensure USACE manages the WVS for its authorized purposes as required by Congress while also meeting its requirements under the

ESA (Chapter 1.0). Management of the WVS for its authorized purposes necessitates ongoing and future operation of the system and maintenance at any given project that responds to changes in WRB conditions and new information related to system operations and technology, the affected environment, polices, and regulations such as the ESA.

## 1.4 COOPERATING AGENCIES

As the lead agency for this PEIS, USACE invited agencies with jurisdiction by law or special expertise relevant to the WVS and its O&M to be cooperating agencies in compliance with 40 CFR 1501.6. Cooperating agencies listed on the cover page contributed to the PEIS by providing information and input throughout the PEIS planning and document preparation process. Additional information on each agency is provided in Appendix L.

In addition to being cooperating agencies, BPA and BOR are action agencies for the ongoing and upcoming ESA Section 7 consultation with NMFS and USFWS, respectively, for the O&M of the WVS. These four federal agencies have met weekly with USACE to improve understanding and provide real-time feedback on the PEIS in general; this engagement informed the formulation and evaluation of the proposed action and the preferred alternative. Coordination was carried out at the technical team level, local leadership level, and regional leadership level. NEPA related topics were discussed with the greater cooperating agency group in the monthly meetings.

## 1.5 USACE-MANAGED DAMS AND RESERVOIRS IN THE WILLAMETTE RIVER BASIN

Congress authorized USACE to construct, operate, and maintain the WVS for flood control purposes beginning in 1938. Subsequently, USACE constructed 13 dams and extensive bank protection revetments along the Willamette River and its tributaries, creating the WVS by the 1970s. The WVS was originally authorized by the Flood Control Act (FCA) of 1938, including authorization for the following dam construction projects: Fern Ridge on the Long Tom River, Dorena and Cottage Grove in the Coast Fork Willamette sub-basin, Lookout Point on the Middle Fork Willamette River, and Detroit on the North Santiam River.

Subsequent FCAs authorized the following dams: Big Cliff on the North Santiam River, Green Peter on the Middle Santiam River, Foster on the South Santiam, Cougar and Blue River on the McKenzie River, Hills Creek and Dexter on the Middle Fork Willamette River, and Fall Creek on Fall Creek, a tributary to the Middle Fork Willamette River.

The WVS includes 100 miles of revetments along the mainstem and tributaries of the Willamette River. The WVS also includes five fish hatcheries.

All 13 dams are operated for multiple uses (See Section 1.7 for detail on authorized purposes). While the WVS is operated as a whole, each dam and reservoir within the WVS is authorized for a specific set of purposes by Congress. Three are re-regulating dams (i.e., used to even out peak discharges of water utilized for power generation at an upstream dam, thereby controlling downstream river level fluctuations). Eight of the 13 dams are operated as hydropower dams (USACE, 2019b).

The locations of the 13 USACE-managed dams and reservoirs in the WVS are shown in Figure 1.2-1. Dams with or without hydropower are indicated, as well as which dams are re-regulating dams. Adult fish collection facilities, hatcheries, and control points of the dams are also shown.

This system of dams and revetments prevent about $900 million annually in flood damages to the Willamette Valley. Urbanization of the floodplain has continued - partially due to the reduction and management of flooding in the WRB resulting from the WVS. Since the construction of the WVS, the population in the geographic area of this system has continued to grow substantially (USACE, 2019a).

Table 1.5-1 summarizes authorized purposes for each project in the WVS.

Table 1.5-2 identifies the dam length, height, elevation, reservoir length, area when full, number of generators, and total output of generators for each of the 13 projects, organized by sub-basin.

Table 1.5-3 identifies tributaries in the WRB and the river mile (RM) location for their respective confluences with the Willamette River.

Following the summary tables is a brief description of each WVS project, organized by WRB sub-basin. The sub-basins and projects are presented in the approximate order of where their flow enters the Willamette River from upstream to downstream.

**Table 1.5-1. Authorized Purposes by Project in the WVS**

| Authorized Purpose | Detroit | Big Cliff | Green Peter | Foster | Cougar | Blue River | Hills Creek | Lookout Point | Dexter | Fall Creek | Dorena | Cottage Grove | Fern Ridge |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flood Control | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | – | ✓ | ✓ | ✓ | ✓ |
| Irrigation | ✓ | – | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | – | ✓ | ✓ | ✓ | ✓ |
| Navigation | ✓ | – | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | – | ✓ | ✓ | ✓ | ✓ |
| Hydropower | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | |
| Fish and Wildlife | ✓ | – | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | – | ✓ | ✓ | ✓ | ✓ |
| Water Quality | ✓ | – | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | – | ✓ | ✓ | ✓ | ✓ |
| Recreation | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Water Supply | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

**Table 1.5-2. WVS Dams Pertinent Data**

| Project | Dam Length (feet) | Height (feet) | Elevation (feet NGVD) | Reservoir Length (miles) | Area When Full (acres) | No. of Generators | Total Output of Generators (MW) |
|---|---|---|---|---|---|---|---|
| **Middle Fork Willamette Sub-basin** | – | – | – | – | – | – | – |
| Hills Creek | 2,235 | 304 | 1,548 | 7.6 | 2,735 | 2 | 36 |
| Lookout Point | 3,381.5 | 276 | 941 | 14.2 | 4,360 | 3 | 146 |
| Dexter | 2,738 | 93 | 702.5 | 2.8 | 1,024.5 | 1 | 17 |
| Fall Creek | 5,100 | 205 | 839 | 6.8 | 1,820 | 0 | n/a |
| **Coast Fork Willamette Sub-basin** | – | – | – | – | – | – | – |
| Cottage Grove | 1,750 | 95 | 808 | 3 | 1,156 | 0 | n/a |
| Dorena | 2,600 | 145 | 866 | 5 | 1,749 | n/a[1] | n/a |
| **McKenzie River Sub-basin** | – | – | – | – | – | – | – |
| Blue River | 1,265 | 270 | 1,362 | 6.4 | 1,009 | 0 | n/a |
| Cougar | 1,600 | 452 | 1,700 | 6 | 1,280 | 2 | 30 |
| **Long Tom River Sub-basin** | – | – | – | – | – | – | – |
| Fern Ridge | 6,330 | 44 | 379.5 | 4.5 | 9,000 | 0 | n/a |
| **South Santiam River Sub-basin** | – | – | – | – | – | – | – |
| Green Peter | 1,500 | 327 | 941 | 10 | 3,720 | 2 | 98 |
| Foster | 4,565 | 126 | 702.5 | 3.5 | 1,220 | 2 | 24 |
| **North Santiam River Sub-basin** | – | – | – | – | – | – | – |
| Detroit | 1,523.5 | 463 | 1,580 | 9 | 3,500 | 2 | 127.8 |
| Big Cliff | 280 | 191 | 1,212 | 2.8 | n/a | 1 | 23 |

NGVD = National Geodetic Vertical Datum; MW = megawatt; n/a= not applicable

Source: USACE, 2020a.

[1] Dorena Dam houses privately owned generates as a part of the privately owned (under a Federal Energy Regulation Commission licensed) and run hydropower. USACE does not operate Dorena Dam for hydropower and any hydropower production is incidental.

**Table 1.5-3. Willamette River Basin Tributaries and the River Mile at their Confluence with the Willamette River**

| Tributary | Willamette River Confluence River Mile |
|---|---|
| Middle Fork / Coast Fork | 188 |
| McKenzie River | 177 |
| Long Tom River | 148 |
| Santiam River | 108 |

### 1.5.1 Middle Fork Willamette Sub-basin

The Middle Fork Willamette sub-basin is situated at the southern (upstream or headwaters) end of the WRB and has a drainage area of about 1,569 square miles, or 14 percent of the entire WRB (Figure 1.5-1). This sub-basin ranges in elevation from 450 feet at Eugene, Oregon, to 8,790 feet at Diamond Peak. Most of this sub-basin is located within national forests and contains four WVS reservoirs: Hills Creek, Lookout Point, Dexter, and Fall Creek.

#### *1.5.1.1 Hills Creek*

Hills Creek Dam and Reservoir is located on the Middle Fork Willamette River 4 miles southwest of Oakridge, Oregon (Figure 1.5-2). The dam is an earth-fill structure that was completed in 1962 with a gated concrete spillway and outlet works for regulating reservoir levels (USACE, 2020a; USACE, 2015). The reservoir provides 350,000 acre-feet of storage and controls runoff for a 390-square-mile drainage area. The dam has two hydropower generating units capable of producing a total of 36 megawatts (MW). This project is authorized for the purposes of flood control, irrigation, navigation, hydropower, fish and wildlife, water quality, recreation, and water supply (USACE, 2020a).

#### *1.5.1.2 Lookout Point*

Lookout Point Dam and Reservoir is located on the Middle Fork Willamette River about 22 miles southeast of Eugene, Oregon (Figure 1.5-3). The dam is an earth and gravel-filled structure with concrete gated spillways (USACE, 2020a). The majority of the construction of Lookout Point Dam, including the powerhouse, was completed in 1953. Lookout Point Reservoir provides 438,200 acre-feet of storage.

All three hydropower generating units at this project were completed by 1955 (USACE, 2015) and have a combined capacity of 146 MW (USACE, 2020a). This project is authorized for the purposes of flood control, irrigation, navigation, hydropower, fish and wildlife, water quality, recreation, and water supply.

#### *1.5.1.3 Dexter*

Dexter Dam and Reservoir is located on the Middle Fork of the Willamette River about 22 miles southeast of Eugene, Oregon and 3 miles downstream of Lookout Point Dam . The dam is an earth and gravel-fill embankment structure with concrete gated spillways that regulate power-generating water releases from Lookout Point Dam. The total generation capacity of the hydropower units is 17 MW (USACE, 2020a).

Dexter Dam was completed in 1954 and was authorized for the purposes of hydropower, recreation, and water supply (USACE, 2020a). Dexter Reservoir provides 27,300 acre-feet of storage.

#### *1.5.1.4 Fall Creek*

Fall Creek Dam and Reservoir is located on Fall Creek, a tributary of the Willamette River, about 20 miles southeast of Eugene, Oregon (USACE, 2020a) (Figure 1.5-5). The dam is a rockfill structure with a gated concrete spillway and outlet works for regulating reservoir levels. Fall Creek Reservoir provides 116,000 acre-feet of storage.

Construction of this project was completed in 1965. This project controls runoff from 184 square miles of drainage area and is authorized for the purposes of flood control, irrigation, navigation, fish and wildlife, water quality, recreation, and water supply (USACE, 2020a).

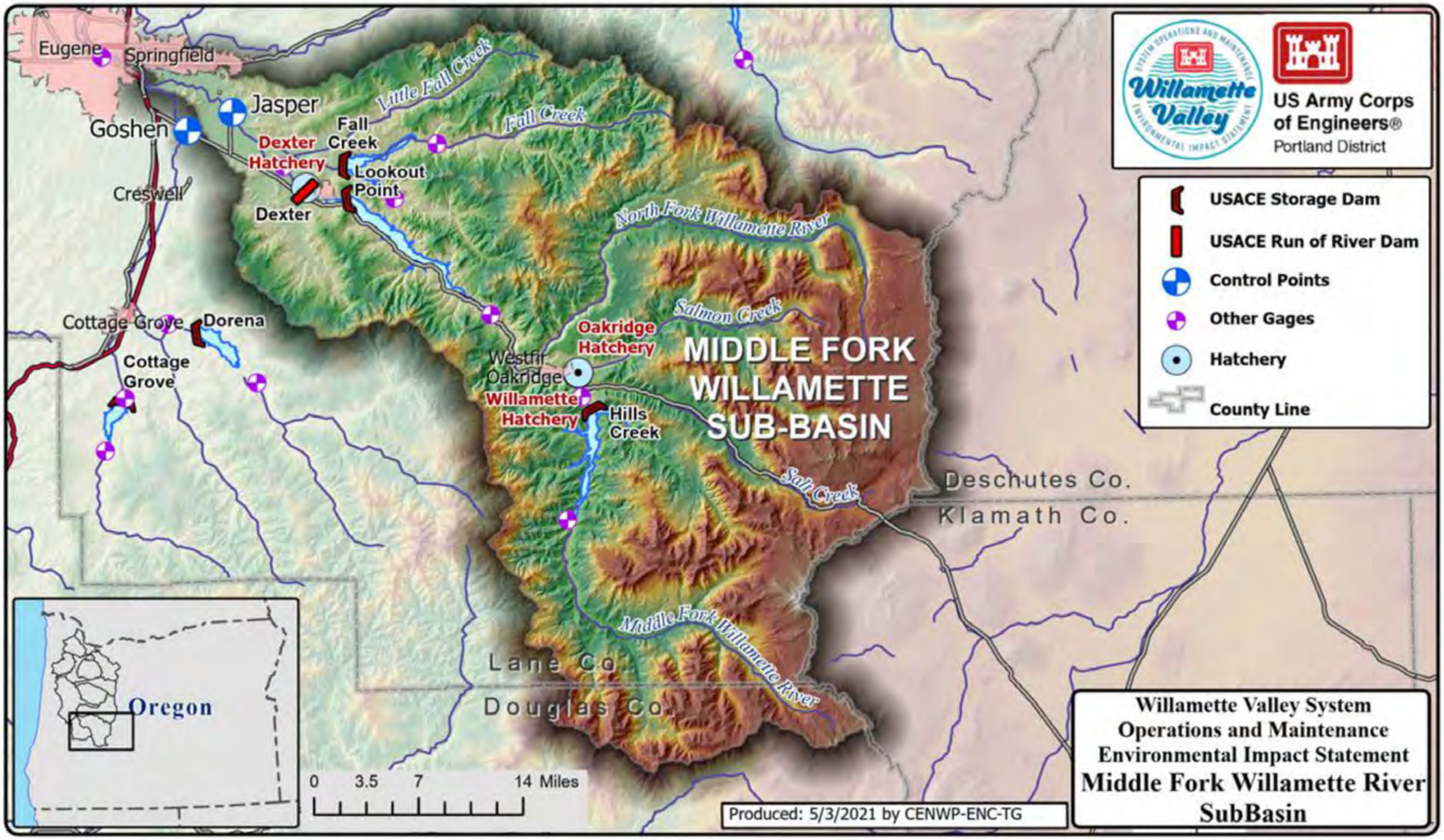


**Figure 1.5-1. Middle Fork Willamette Sub-basin**

**Figure 1.5-2. Hills Creek Dam and Reservoir**

**Figure 1.5-3. Lookout Point Dam and Reservoir**

**Figure 1.5-4. Dexter Dam and Reservoir**

**Figure 1.5-5. Fall Creek Dam and Reservoir**

### 1.5.2 Coast Fork Willamette Sub-basin

The Coast Fork Willamette sub-basin is situated in the southwestern portion of the WRB, directly to the west of the Middle Fork sub-basin described above (Figure 1.5-6). It has a drainage area of approximately 669 square miles, or about 6 percent of the entire WRB.

Elevations in the Coast Fork drainage sub-basin range from about 450 feet at Eugene, Oregon, to 6,000 feet at the headwaters. The drainage headwaters consist largely of steep, rugged, heavily forested mountainous terrain dissected by narrow river valleys. This sub-basin contains two WVS projects: Cottage Grove and Dorena.

#### *1.5.2.1 Cottage Grove*

Cottage Grove Dam and Reservoir sits on the Coast Fork of the Willamette River about 5 miles south of Cottage Grove, Oregon (Figure 1.5-7). The dam is an earth-fill structure with a concrete spillway and controls runoff from 104 square miles of land in the Coast Fork Willamette River watershed. Construction of this project was completed in 1942.

The reservoir provides 31,800 acre-feet of storage. This project is authorized for the purposes of flood control, irrigation, navigation, fish and wildlife, water quality, recreation, and water supply (USACE, 2020a).

#### *1.5.2.2 Dorena*

Dorena Dam and Reservoir is located on the Row River, a tributary of the Willamette River, about six miles east of Cottage Grove, Oregon (Figure 1.5-8). The dam is an earth-fill structure with a concrete spillway and controls runoff from 265 square miles of drainage area. The reservoir provides 72,100 acre-feet of storage. This project was completed in 1949 and is authorized for the purposes of flood control, irrigation, navigation, fish and wildlife, water quality, recreation, and water supply (USACE, 2020a).

Dorena Dam also includes a privately-operated hydropower unit that began operation in 2014 and is licensed by Federal Energy Regulation Commission. The unit consists of two turbines: one high flow and one low flow. Only one of the units is in operation at any given time, meaning that roughly half of the generating capacity is utilized depending on flow conditions.

The hydropower unit is a run-of-the-river plant that utilizes the flows released from the Dorena Lake reservoir. The run-of-the-river designation means that the plant does not control flows, but rather uses the flows dictated by USACE operation of Dorena Dam. Any hydropower production at Dorena Dam is incidental to how USACE operates the dam and does not substantially affect any of the USACE multipurpose missions.

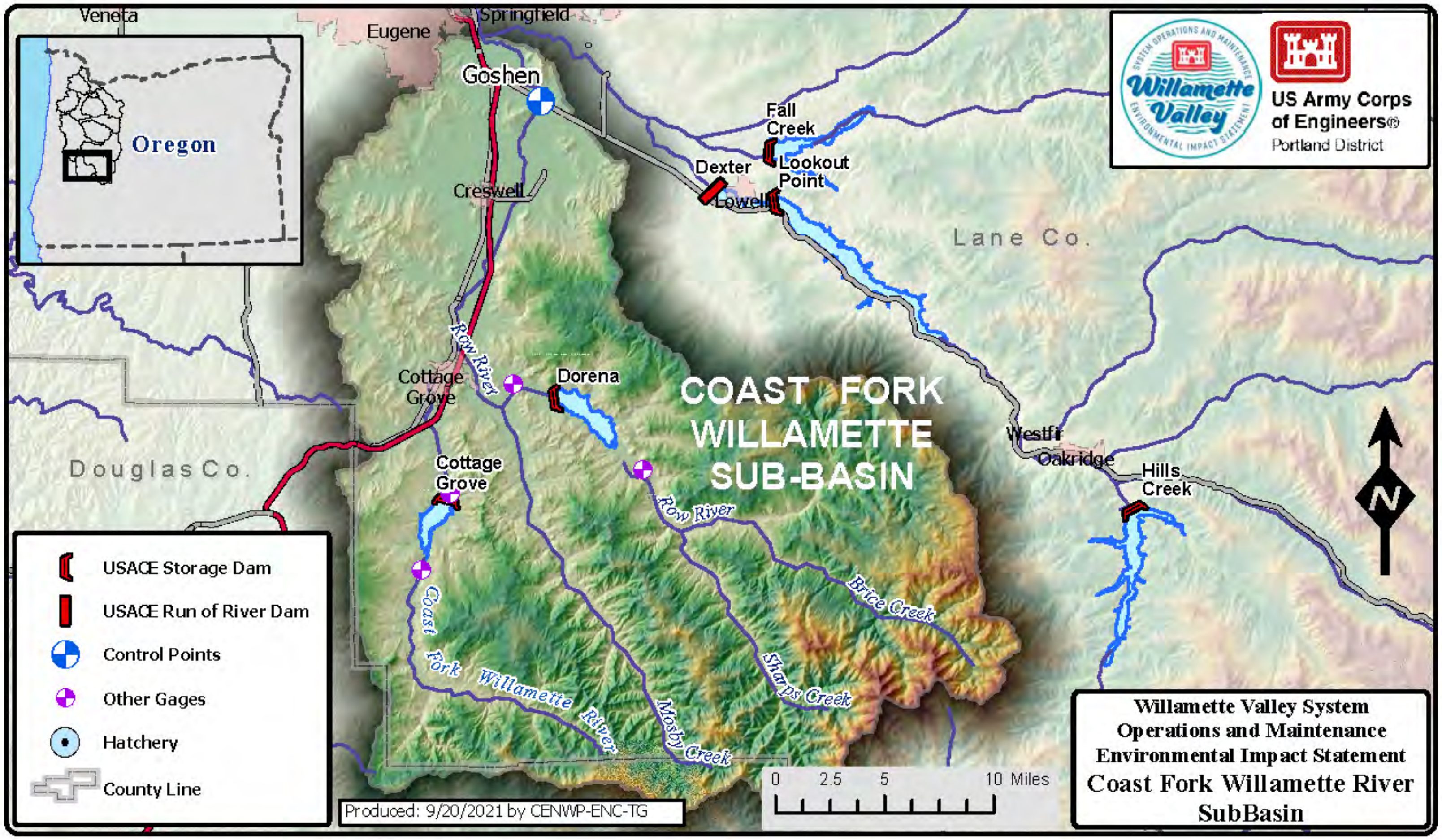


**Figure 1.5-6. Coast Fork Willamette Sub-basin**

**Figure 1.5-7. Cottage Grove Dam and Reservoir**

**Figure 1.5-8. Dorena Dam and Reservoir**

### 1.5.3 McKenzie River Sub-basin

The McKenzie River sub-basin is situated in the southeast portion of the WRB and has a drainage area of approximately 1,300 square miles, or 12 percent of the WRB (Figure 1.5-9). The McKenzie River is about 90 miles long and joins the mainstem Willamette River a few miles north of Eugene, Oregon. Elevations within the sub-basin range from 350 feet to 6,650 feet. Higher elevations in the headwaters of the sub-basin are rugged and heavily forested.

The McKenzie River sub-basin contains two WVS projects: Blue River and Cougar. Two non-federal projects are also located in the McKenzie River sub-basin: Carmen-Smith Hydroelectric Project on the upper McKenzie River and Leaburg-Walterville Hydroelectric Project on the lower McKenzie River.

#### *1.5.3.1 Blue River*

Blue River Dam and Reservoir is located on a tributary of the McKenzie River about 38 miles east of Eugene, Oregon (USACE, 2020a) (Figure 1.5-10). The dam is a rockfill structure with a gated concrete spillway. The reservoir provides 82,800 acre-feet of storage and controls runoff from an 88-square-mile drainage area (USACE, 2020a).

This project was completed in 1969 and is authorized for the purposes of flood control, irrigation, navigation, hydropower, fish and wildlife, water quality, recreation, and water supply (USACE, 2020a). It should be noted that while hydropower is one of this project’s authorized purposes, no generators have been constructed or installed at this project.

#### *1.5.3.2 Cougar*

Cougar Dam and Reservoir is located on the South Fork McKenzie River, a Willamette tributary, about 42 miles east of Eugene, Oregon. Cougar Reservoir has a storage capacity of 189,000 acre-feet and controls runoff from an area of 208 square miles (USACE, 2020a). The dam is a rockfill structure with a gated concrete spillway that was completed in 1964.

This project is authorized for the purposes of flood control, irrigation, navigation, hydropower, fish and wildlife, water quality, recreation, and water supply. The total capacity of the two hydropower generating units at this project is 30 MW (USACE, 2020a). In 2004, USACE completed construction of a water temperature control (WTC) tower at Cougar Dam, which improved downstream conditions for ESA-listed fish species (Figure 1.5-12).

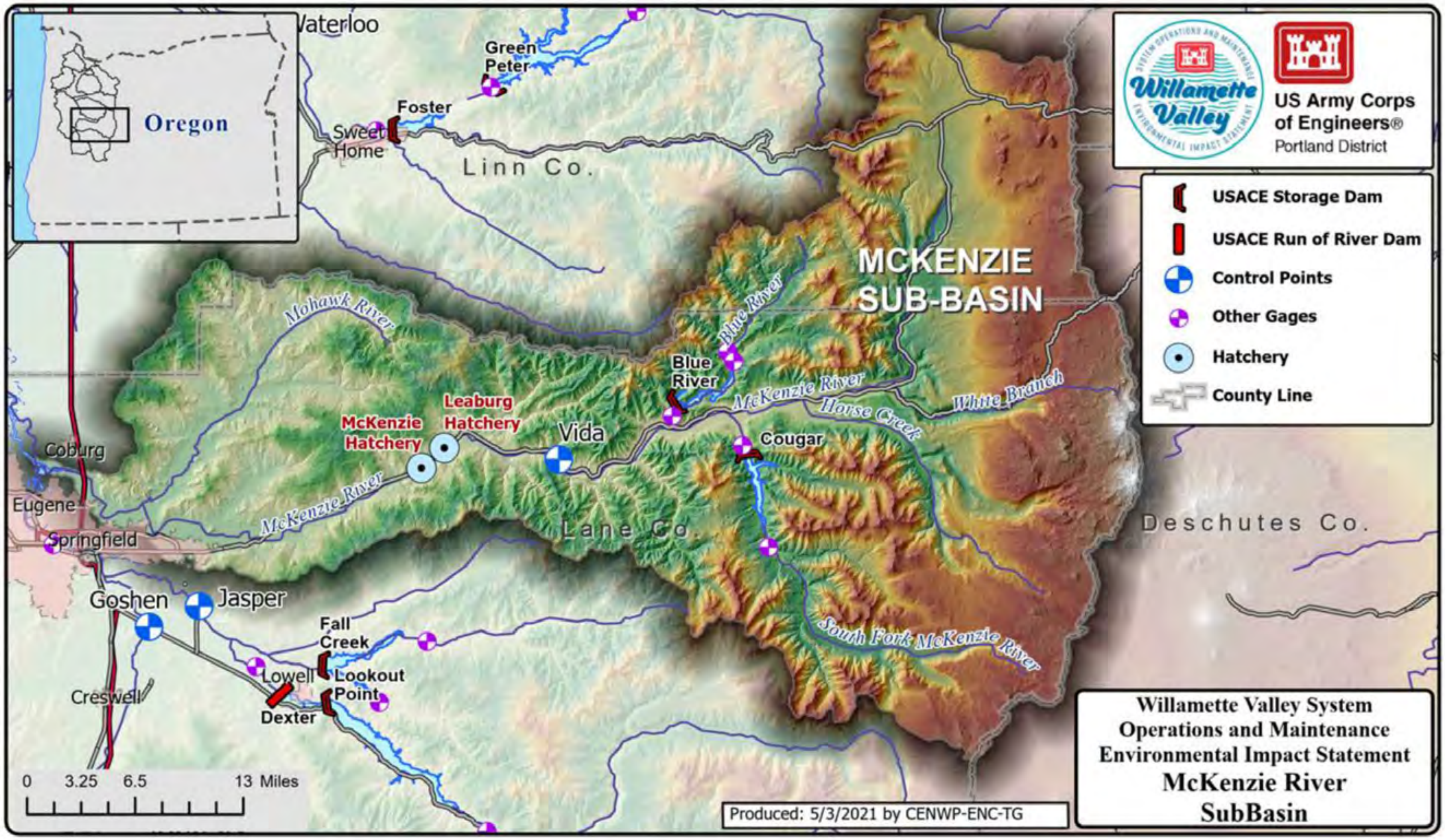


**Figure 1.5-9. McKenzie River Sub-basin**

**Figure 1.5-10. Blue River Dam and Reservoir**

**Figure 1.5-11. Cougar Dam and Reservoir**

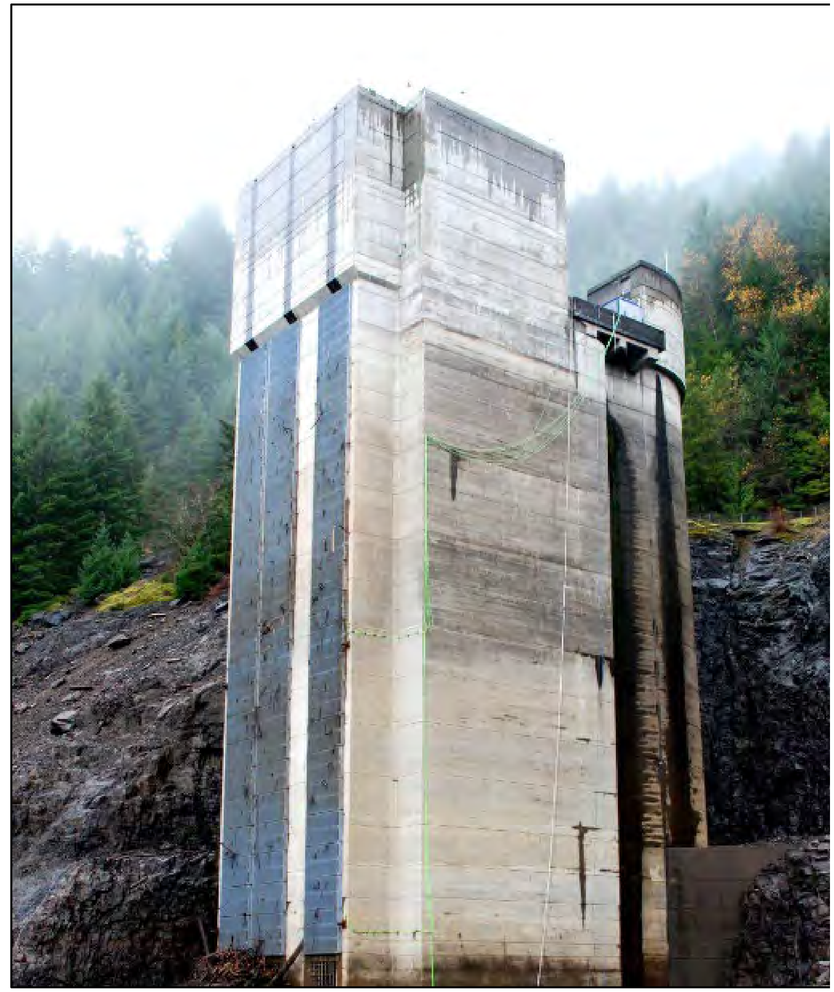

**Figure 1.5-12. Water Temperature Control Tower at Cougar Dam**

### 1.5.4 Long Tom River Sub-basin

The Long Tom River sub-basin is situated in the southwest portion of the WRB, north of the Coast Fork sub-basin. It is relatively low-lying, with a maximum elevation of 2,125 feet (Figure 1.5-13). The Long Tom River sub-basin includes one WVS project: Fern Ridge. Below Fern Ridge Dam, the Long Tom River meanders before joining the mainstem Willamette River north of Monroe, Oregon. The Long Tom River below Fern Ridge Dam is channelized with embankments. The river was shortened from 36.5 miles to 23.6 miles.

A series of seven drop structures were also built with the intent to reduce channel velocity and decrease erosion, while still moving water downstream efficiently. Three of the seven drop structures, one at Monroe (RM 6.7), one at the Stroda property (RM 10.2), and one just upstream of Ferguson Road (RM 12.7), are constructed of concrete and range in height from 7.5 feet-11.5 feet. The remaining four are smaller rock riffle weirs and are located in the uppermost 4 miles of the constructed channel. Operation and maintenance of all seven structures is minimal.

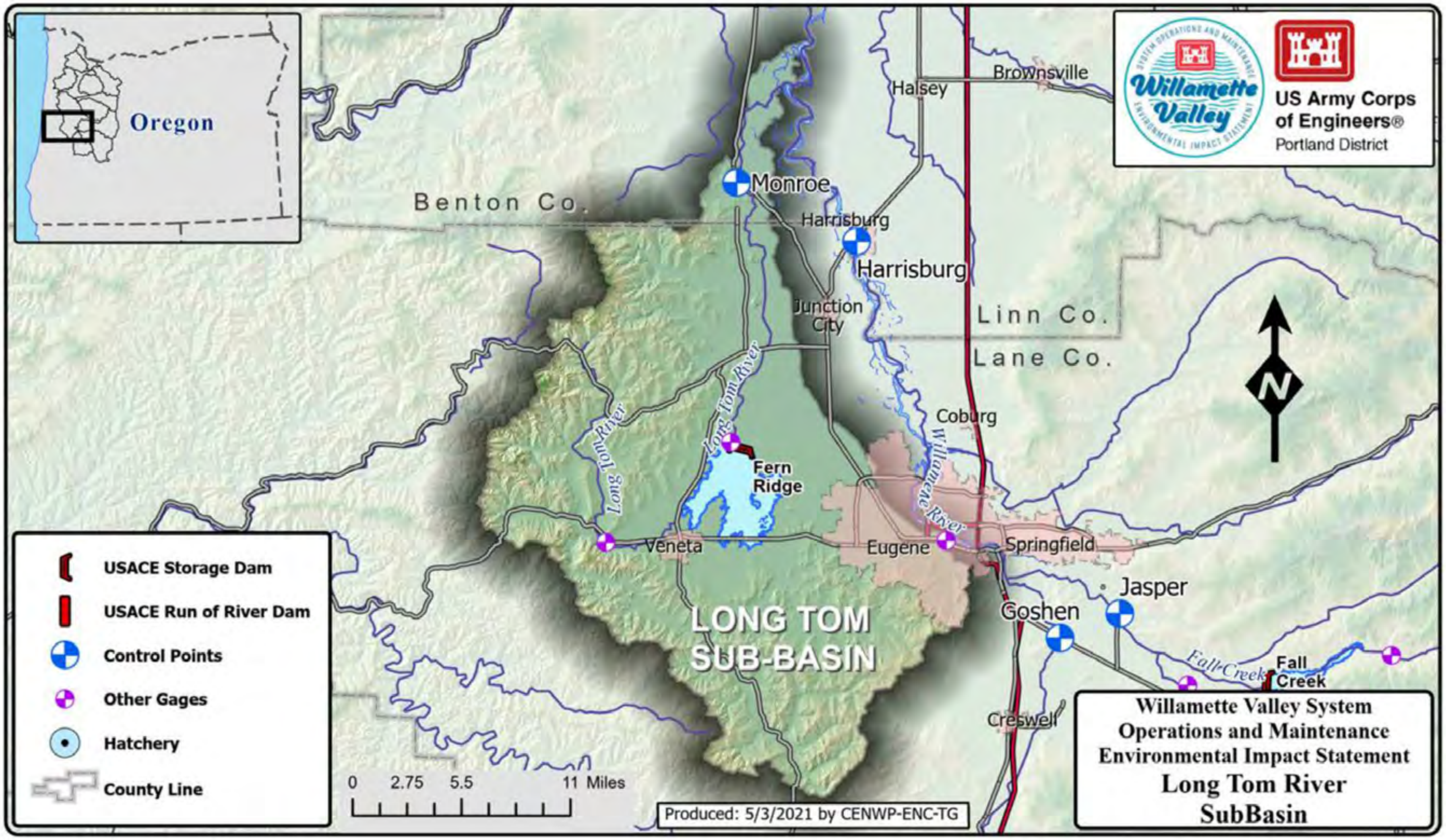


**Figure 1.5-13. Long Tom River Sub-basin**

#### *1.5.4.1 Fern Ridge*

Fern Ridge Dam and Reservoir is on the Long Tom River, a tributary of the Willamette River, about 12 miles west of Eugene, Oregon (Figure 1.5-14); it is the only dam in the WVS west of Interstate 5. Fern Ridge Dam is an earth-fill structure that includes a gated concrete spillway and outlet works for regulating reservoir levels. The dam was completed in 1941 and was the first WVS dam constructed by USACE (USACE, 2020a).

The reservoir provides 97,300 acre-feet of storage and controls runoff from a 275-square-mile drainage area. This project is authorized for the purposes of flood control, irrigation, navigation, fish and wildlife, water quality, recreation, and water supply (USACE, 2020a).

In 1950, a project was completed that altered the lower Long Tom River from the dam to its confluence with the Willamette River. Alterations to the Long Tom River were made to control the subsequent flooding created by the Fern Ridge dam construction, enabling USACE to maintain the FRM mission downstream of the dam.

In 1965 the dam was raised 1.6 feet for additional storage and in 1987 the spillway and outlet works were modified. A Supervisory Control and Data Acquisition system was installed to control the spillway gates in 1992 (USACE, 2015).

In 2005-2006, USACE repaired the failed internal drainage system in the earth-fill embankment, which had caused depressions and seepage on the downstream dam slope. Repair work included excavation of the downstream face of the dam, replacement of the drainage system, and reconstruction of the embankment (DJC, 2005).

**Figure 1.5-14. Fern Ridge Dam and Reservoir**

### 1.5.5 South Santiam River Sub-basin

The Santiam River sub-basin is situated in the east-central part of the WRB and encompasses a drainage area of approximately 1,827 square miles, or about 16 percent of the WRB. This sub-basin includes the North, Middle, and South Santiam Rivers (Figure 1.5-15). The Santiam River sub-basin elevations range between 200 feet and 10,495 feet and average 2,040 feet above mean sea level.

The South Santiam River, roughly 66 miles long, drains an area of approximately 1,040 square miles in geologically older terrain. The Middle Santiam River, a tributary of the South Santiam River, flows through steep, heavily forested mountain terrain, draining an area of 287 square miles.

The Middle and South Santiam rivers meet in Foster Reservoir; from there, the South Santiam flows northwest to near Jefferson where it joins the North Santiam River to form the mainstem Santiam River. The mainstem Santiam River flows for 11.7 miles to its confluence with the Willamette River. There are two WVS projects in the South Santiam sub-basin: Green Peter and Foster.

#### *1.5.5.1 Green Peter*

Green Peter Dam and Reservoir is located on the Middle Santiam River (within the South Santiam River sub-basin), 11 miles northeast of Sweet Home, Oregon (Figure 1.5-16). The dam is a concrete structure with a gated spillway. Construction of this project was completed in 1967 and it is authorized for the purposes of flood control, irrigation, navigation, hydropower, fish and wildlife, water quality, recreation, and water supply.

The Green Peter Reservoir provides 409,800 acre-feet of storage. The total output of this project's two hydropower generating units is 98 MW (USACE, 2020a).

#### *1.5.5.2 Foster*

Foster Dam and Reservoir is located on the South Santiam River at the confluence of the South Santiam and Middle Santiam Rivers, approximately 4 miles northeast of Sweet Home, Oregon (Figure 1.5-17). Foster Dam is a rockfill structure with a concrete gated spillway used to regulate power-generating water releases from Green Peter Dam and flows from the South Santiam River (USACE, 2020a).

Construction of this project was completed in 1968. Foster Reservoir provides 55,900 acre-feet of storage. This project is authorized for the purposes of flood control, irrigation, navigation, hydropower, fish and wildlife, water quality, recreation, and water supply. The total output of this project's two hydropower generators is 24 MW (USACE, 2020a).

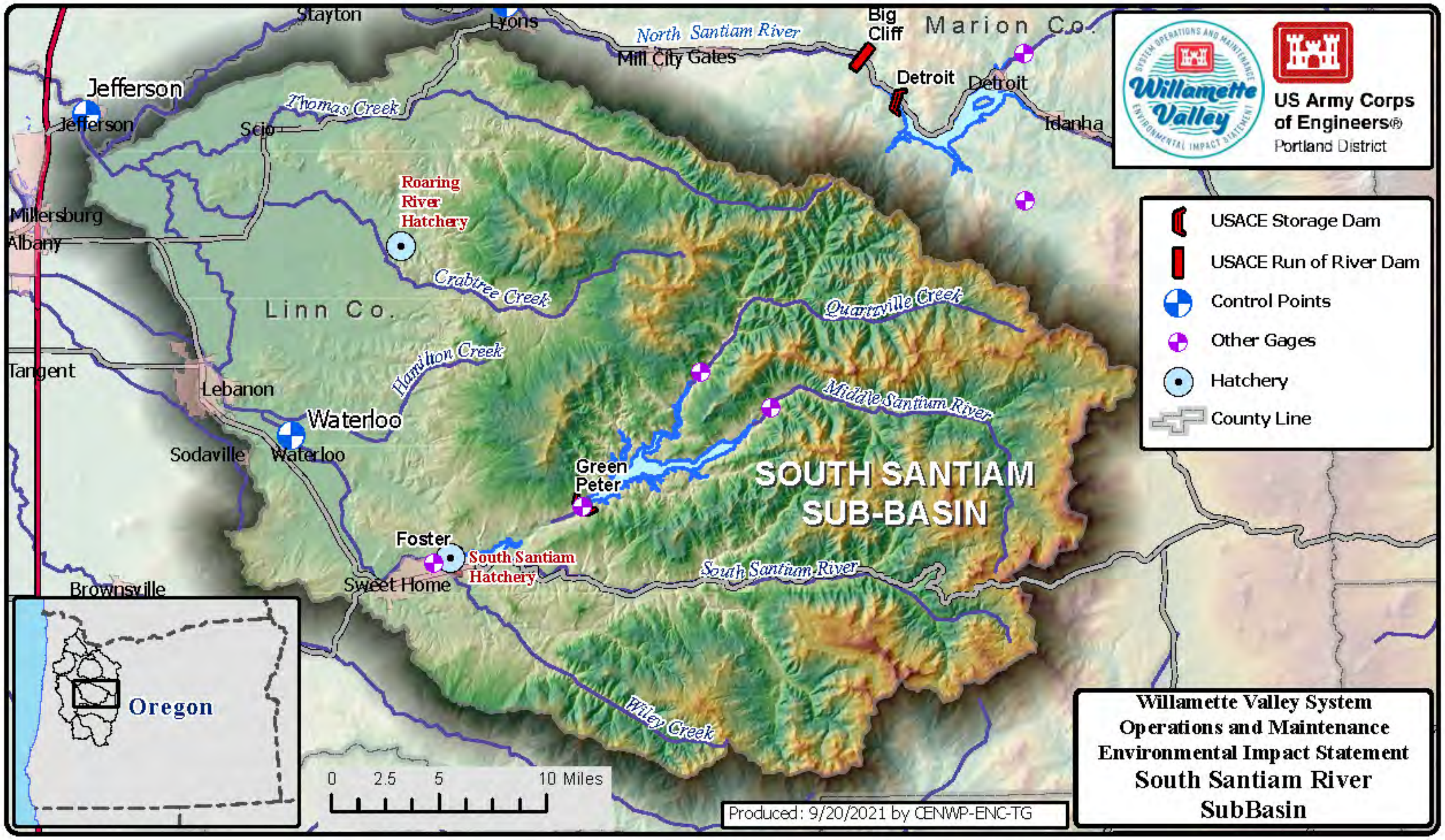


**Figure 1.5-15. South Santiam River Sub-basin**

**Figure 1.5-16. Green Peter Dam and Reservoir**

**Figure 1.5-17. Foster Dam and Reservoir**

### 1.5.6 North Santiam River Sub-basin

The North Santiam River sub-basin is situated in the east-central portion of the WRB and is about 92 miles long (Figure 1.5-18). It drains an area of approximately 655 square miles, or about six percent of the WRB.

The sub-basin contains heavily forested watersheds and high plateaus with scattered volcanic peaks and rugged slopes in the Cascades. The North Santiam sub-basin contains two WVS projects: Detroit and Big Cliff.

#### *1.5.6.1 Detroit*

Detroit Dam and Reservoir is located on the North Santiam River approximately 50 miles southeast of Salem, Oregon (Figure 1.5-19). At full pool elevation (1,569 feet), Detroit Reservoir covers an area of 3,580 acres with 428,800 acre-feet of usable storage at the confluence of the North Santiam and Breitenbush Rivers (USACE, 2019b).

The concrete gravity dam was constructed primarily for FRM (USACE, 2020a), though its authorized purposes also include irrigation, navigation, hydropower, fish and wildlife, water quality, recreation, and water supply.

In 1953 construction was completed, the spillway gates and two generators were installed, and initial power from the first generator was delivered to the Bonneville Power Administration (USACE, 2015). The total output of this project’s two hydropower generators is 127.8 MW (USACE, 2020a).

#### *1.5.6.2 Big Cliff*

Big Cliff Dam and Reservoir is located about 3 miles downstream of the Detroit Dam on the North Santiam River, about 45 miles southeast of Salem, Oregon (Figure 1.5-20). Big Cliff Dam is a re-regulating, concrete structure with gated spillways. Big Cliff Reservoir is a small reservoir that provides 6,430 acre-feet of storage. It is used to even out peak discharges of water utilized for power generation at Detroit Dam, thereby controlling downstream river level fluctuations (USACE, 2019b).

This project was completed in 1954 and is authorized for the purposes of hydropower, recreation, and water supply. The total output of this project’s single generator is 23 MW (USACE, 2020a).

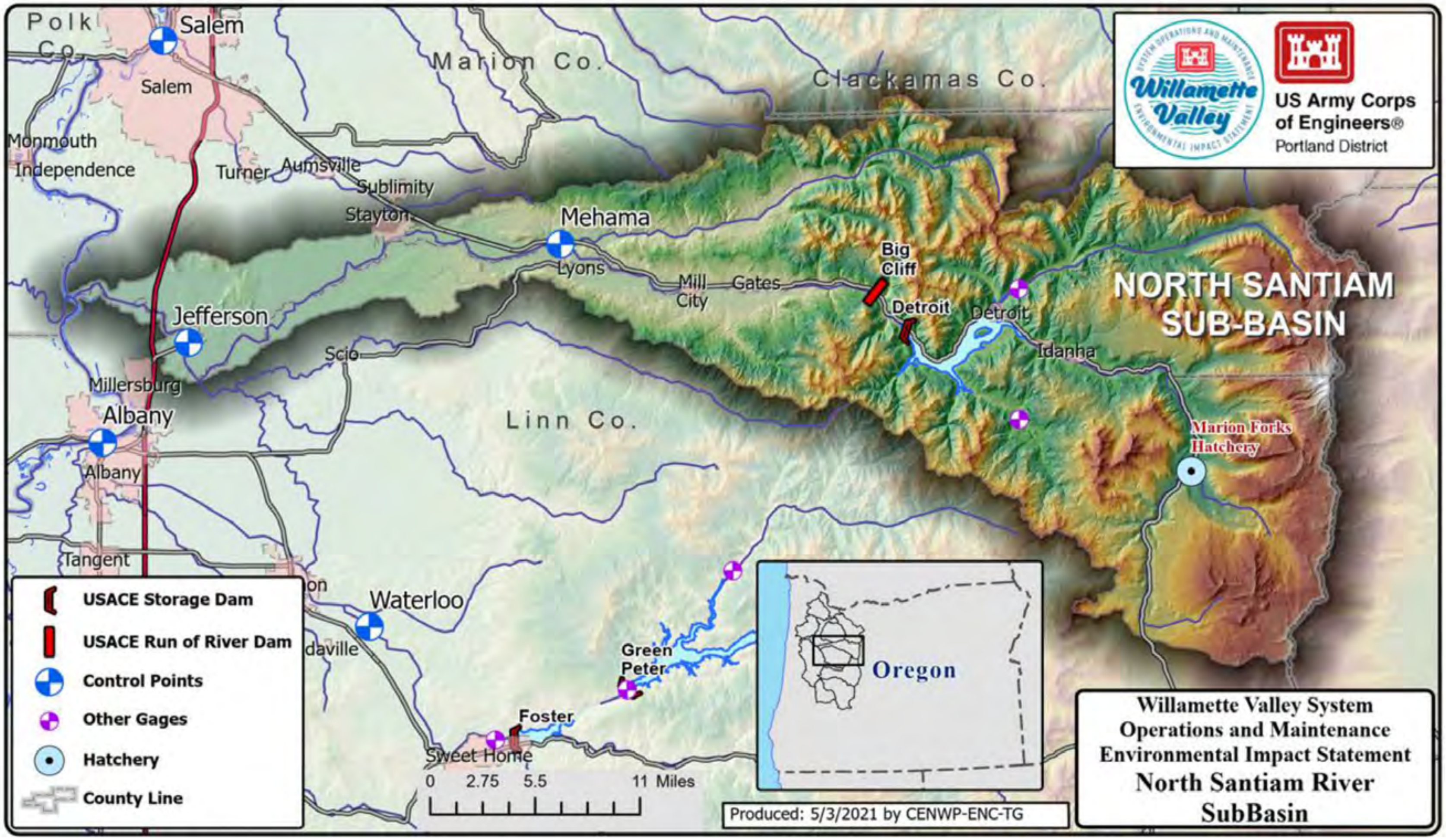


**Figure 1.5-18. North Santiam River Sub-basin**

**Figure 1.5-19. Detroit Dam and Reservoir**

**Figure 1.5-20. Big Cliff Dam and Reservoir**

## 1.6 USACE PROGRAMS IN THE WILLAMETTE RIVER BASIN

In addition to operations of the dams and reservoirs throughout the WVS, USACE manages several ongoing programs in the WRB. These include the Willamette River Basin Bank Protection Program (WRBBPP), the Willamette Hatchery Mitigation Program; Adult Fish Collection facilities; and the Research, Monitoring, and Evaluation (RM&E) program.

### 1.6.1 Willamette River Basin Bank Protection Program

USACE is responsible for the WRBBPP, originally authorized by the 1936 FCA. Authorization of the WRBBPP allowed USACE to construct and maintain 450,000 linear feet of bank protection works. In 1971, the Senate and House Committees on Public Works expanded the program's scope to 510,000 linear feet (USFWS, 2008). The program uses bank protection structures (e.g., riprap revetments, steel pile bulkheads, timber bulkheads, drift barriers, and earthen embankments) to prevent bank erosion (USACE, 2000).

The Water Resources Development Act (WRDA) of 1950 required local sponsorship for any new bank protection projects and transferred responsibility for maintenance of revetments constructed after 1950 from USACE to the local sponsor (USFWS, 2008).

USACE was responsible for the construction of 223 flood control structures in the WRB. Of these structures 193 structures are still active; 88 of these are maintained by USACE; 105 structures are maintained by their local sponsor (USACE, 2000).

A hydraulic, hydrologic, and geomorphic investigation of consequence was conducted in 2013 for 60 USACE-maintained revetment projects in the WRB. The remaining 28 USACE-maintained revetments were excluded from the study because they were either destroyed or located substantially off the main channel and are no longer serving their intended purpose. Though requested, a lack of funding over the past decades has prevented significant maintenance, repair, or replacement of the structures under USACE's control.

### 1.6.2 Willamette Hatchery Mitigation Program

Construction of the dams adversely impacted UWR spring Chinook salmon, UWR winter steelhead, resident trout, including the ESA-listed bull trout, and Pacific lamprey by physically blocking their migrations to and from habitat upstream of the dams and by inundating some habitat through the creation of reservoirs. In addition, construction of the dams and reservoirs submerged existing hatcheries on the Middle Fork Willamette, North Santiam, and South Santiam Rivers and required the relocation of existing hatchery brood egg-collection stations on the Middle Fork Willamette, McKenzie, North Santiam, and South Santiam Rivers.

The WVS was authorized with the full recognition that it would cut off extensive areas of upstream habitat for migratory salmon and steelhead (House Document 81-531, App. J, 1732 (1950)) (HD531). To mitigate for the loss of migratory corridors and inundation of habitat and existing hatcheries, Congress also authorized USACE to carry out the Willamette Hatchery

Mitigation Program to produce and release hatchery salmon, steelhead, and resident trout in the WRB.

HD531 also acknowledged that the projects could adversely impact anadromous fishes because they created physical barriers to migration and habitat loss associated with controlled inundation for the reservoirs. Consequently, HD531 provided for production mitigation to offset fish losses due to construction and operation of Willamette Valley projects.

Congress did not define detailed goals for the fish mitigation program (e.g., the level of fish production to be achieved), allowing USACE to determine how to implement the program within the WRB, whether through hatchery programs, passage improvements, or a combination of those measures. Although some of the dams built in the 1960s included fish passage features, including Foster, Green Peter, Fall Creek and Cougar dams, these facilities were unsuccessful (Schwartz and McCroskey, 2021). USACE also developed hatchery programs to mitigate for adverse impacts to fish passage.

USACE funds the operation and maintenance of five hatcheries for mitigation and conservation within the WVS (Figure 1.6-2). The USACE hatchery program is conducted in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins. The hatchery programs within these sub-basins include UWR spring Chinook salmon, UWR summer steelhead, and rainbow trout. These five hatcheries contribute to the UWR Chinook salmon Evolutionarily Significant Unit[3] (ESU). UWR summer steelhead and rainbow trout are produced exclusively for sport harvest interests. The purpose of the conservation hatchery program is to supplement the natural origin population and support reintroduction of spring UWR Chinook salmon in the WVS due to very low abundances, high extinction risks, and lack of fish passage at some WVS projects.

Recently completed Hatchery Genetic Management Plans (HGMPs), prepared jointly by ODFW and USACE for compliance with the ESA, provide the most up-to-date definition of hatchery fish production commitments for the USACE Willamette Hatchery Mitigation Program (NMFS, 2019)[4]. Hatchery performance goals are driven by standards and performance targets identified in the HGMPs for the North Santiam, South Santiam, McKenzie, and Middle Fork WRB. A brief description of the five hatcheries in these four sub-basins is provided below (Figure 1.6-2).

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[3] Under the Endangered Species Act, an evolutionarily significant unit—or ESU— is a Pacific salmon population or group of populations that is substantially reproductively isolated from other conspecific populations and that represents an important component of the evolutionary legacy of the species.

[4] "HGMPs are technical documents that thoroughly describe the composition and operation of each individual hatchery program. The primary goal of an HGMP is to describe biologically-based artificial propagation management strategies that ensure the conservation and recovery of ESA-listed salmon and steelhead populations. [NMFS], who oversees the ESA for salmon and steelhead, uses the information provided by HGMPs to evaluate impacts on salmon and steelhead listed under the Endangered Species Act. Completed HGMPs may also be used for regional fish production and management planning by federal, state, and tribal resource managers" (https://wdfw.wa.gov/fishing/management/hatcheries/hgmp).

The McKenzie Hatchery was originally an Oregon state hatchery but was expanded by USACE to mitigate the effects of USACE dams on UWR Chinook salmon within the McKenzie River Sub-basin. Leaburg Hatchery was built on the McKenzie River to mitigate for lost fishing opportunities caused by construction of the dams on Willamette Basin rivers. The Leaburg Hatchery rears summer steelhead and Chinook salmon. The ODFW maintains and operates the hatcheries with funds from USACE and the State of Oregon. USACE also promotes resident fisheries throughout the McKenzie River basin through the continued support of Leaburg Hatchery and as a partner with several agencies in efforts to support Oregon chub populations and recover the ESA-listed bull trout within the McKenzie River Sub-basin (USACE, 2020a).

Marion Forks Hatchery (Figure 1.6-1) in the North Santiam River Sub-basin was constructed in 1951 to compensate for the loss of salmon and steelhead habitat caused by construction of both the Detroit and Big Cliff dams without adult fish passage. Minto Fish Facility is an adult fish collection facility located downstream of Big Cliff Dam. USACE constructed the Minto Fish Facility to collect adult UWR Chinook salmon as broodstock (mature individuals used for breeding purposes) to supply eggs for Marion Forks Hatchery (USACE, 2019b).

**Figure 1.6-1. Rearing ponds at Marion Forks Fish Hatchery in the North Santiam Sub-basin**

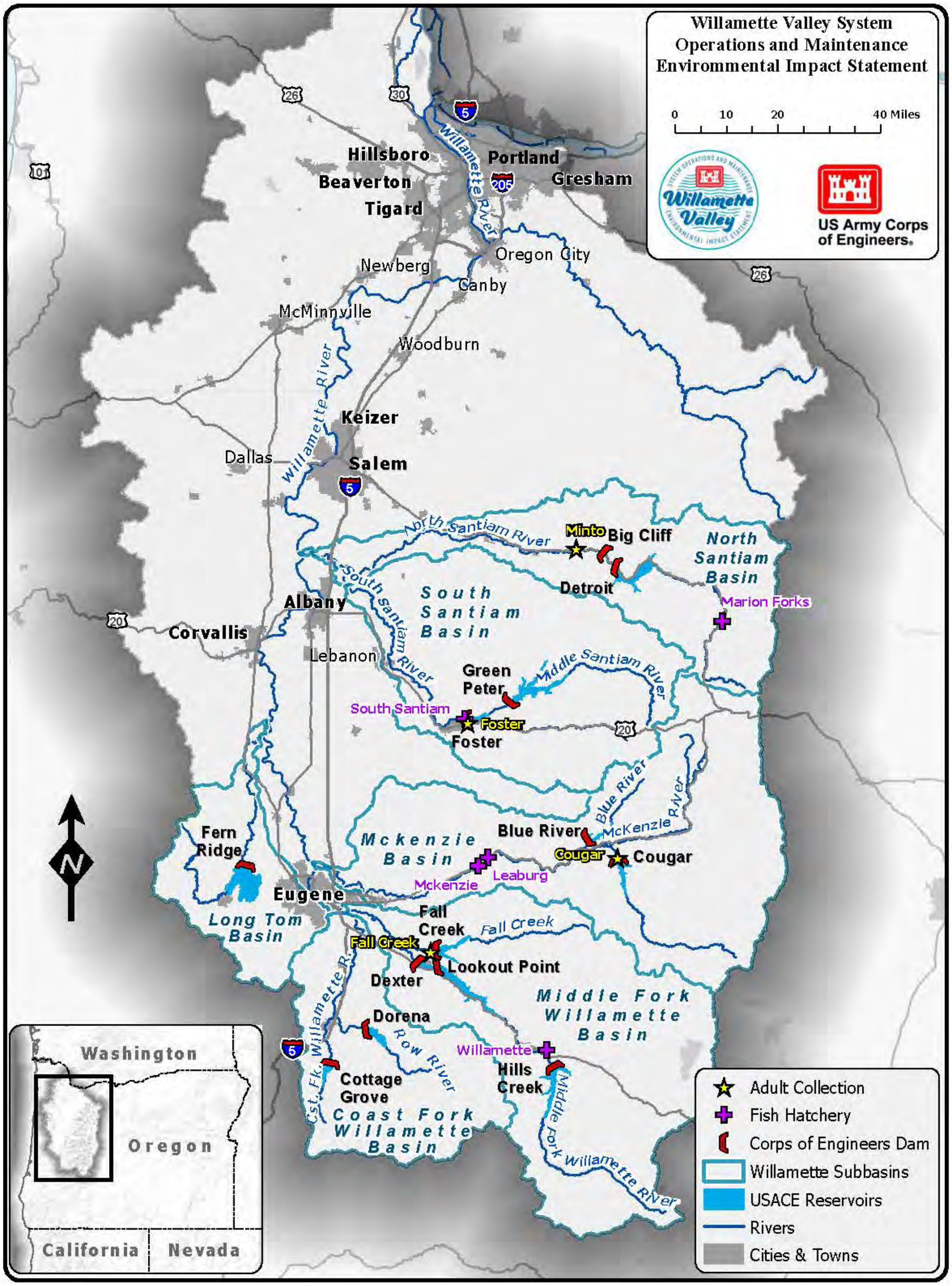


**Figure 1.6-2. WVS Fish Hatcheries and Adult Fish Collection Facilities**

### 1.6.3 Adult Fish Collection Facilities

Dams and reservoirs pose barriers to fish migration, both for their upstream and downstream migrations. For some fish species this can have enormous consequences on the population. In an effort to help reduce these effects and assist with the upstream fish migration, USACE operates and maintains adult fish collection facilities located at Foster, Fall Creek, Minto (downstream of Big Cliff), Cougar (Figure 1.6-3), and Dexter dams (Figure 1.6-2). These facilities, with the exception of the Dexter adult fish collection facility, have been redesigned to accommodate adult salmon and steelhead collection, sorting, outplanting, recycling (summer steelhead), monitoring, and juvenile acclimation of spring UWR Chinook salmon.

Although the design and current operations of the facilities is focused on UWR spring Chinook salmon and UWR winter steelhead, the adult fish collection facilities are also used to pass any native migratory fish species which are collected during the trap operations, including lamprey. Due to the lack of lamprey trapping infrastructure, lamprey passage is a very rare.

Fish that are collected and require transport are loaded in specialized trucks designed for the safe transportation and release of fish (Figure 1.6-4). For fish released above the dam, many release sites have dedicated infrastructure (e.g., release pipes), to reduce injuries and mortality.

**Figure 1.6-3. Cougar Dam Adult Fish Collection Facility**

**Figure 1.6-4. Trap and Haul Tanker Truck**

### 1.6.4 Research, Monitoring and Evaluation

The 2008 NMFS BiOp recognized that information necessary for making informed adaptive management decisions[5], in addition to tracking and documenting progress toward achievement of the RPA measures, was lacking. Additional information was needed on local environmental conditions, specific effects of the WVS on UWR spring Chinook salmon and UWR steelhead, operational constraints, technical feasibility, and effectiveness of action taken to achieve substantive RPA measures. The 2008 NMFS BiOp, therefore, included the development of a comprehensive RM&E program in the RPA to obtain the required information. The RM&E program is run with considerable coordination and input from the WATER team set up by the 2008 BiOp to provide this input[6].

[5] Adaptive management is a systematic approach for improving resource management by learning from management outcomes…An adaptive approach involves exploring alternative ways to meet management objectives, predicting the outcomes of alternatives based on the current state of knowledge, implementing one or more of these alternatives, monitoring to learn about the impacts of management actions, and then using the results to update knowledge and adjust management actions (USFWS, 2009).

[6] WATER, a collaborative advisory body made up of USACE, other federal and state agencies with fisheries and water resource management responsibilities in the WRB, and affected tribes, was established under the 2008 BiOps to coordinate with USACE on operation of the WVS. See Section 1.8.9.

## 1.7 AUTHORIZED PURPOSES

Congress authorized USACE to construct, operate, and maintain the WVS for flood control purposes beginning in 1938. Subsequently, USACE constructed 13 dams and extensive bank protection revetments along the Willamette River and its tributaries, creating the WVS by the 1970s (Section 1.5). The various purposes of the WVS were authorized by the Congress in the Flood Control Acts (FCA) between 1938 and 1962, the Water Supply Act of 1958, and the Water Resources Development Act of 1986. In these acts Congress designated the purpose for each project (Chapter 1.0) (Table 1.5-1). These purposes are described below.

Each of the 13 dams and reservoirs within the WVS are operated according to a water control manual that is authorized by Engineering Regulation 1110-2-240. These manuals provide specific information to meet the congressionally authorized purposes of FRM, generation of hydropower, water supply, irrigation, navigation, recreation, and fish and wildlife. The manuals also detail operations, procedures, and rule curves for each project.

Each manual includes a Drought Contingency Plan, which addresses flow needs, drought management organizations, a drought assessment process, and a framework to carry out a drought response. The draft Master Water Control Manual for the Willamette Valley Project is a compilation of all water control manuals for the 13 dams and reservoirs (USACE, 2015). The draft Manual will be completed following a NEPA review tiered from this PEIS.

### 1.7.1 Flood Risk Management

A primary function of the WVS is FRM. The dams are operated as a system providing FRM on six major tributaries affecting approximately 27 percent of the watershed area upstream of Portland, Oregon. Since 1994, the average annual value of damages prevented by FRM operation of the WVS has been estimated at $900 million (USACE, 2019a). This number is likely low given the growth and development of the WRB. Flood storage is discussed in more detail in Section 1.8.

To efficiently execute its FRM mission, USACE coordinates with multiple partnering agencies.

- National Oceanic and Atmospheric Administration's (NOAA's) Northwest River Forecast Center (NWRFC) is responsible for flood forecasting and is co-located with the National Weather Service (NWS), which is responsible for both meteorological forecasting and the issuance of flood warnings. These two offices coordinate closely with the USACE's Portland District for dissemination of river information and forecasts.
- The Natural Resources Conservation Service (NRCS) is responsible for obtaining hydrologic data. The NRCS Snow Survey monitors snow water content and cumulative precipitation at many stations in the WRB. Both the NRCS and NWS develop volume runoff forecasts in the spring of each year based on data provided by these field stations. These data are essential for planning for the best use of available water to meet the multiple purposes of the WVS.

- The U.S. Geological Survey (USGS) in Portland, with field assistance from their Eugene office, has the responsibility of collecting, calibrating, and publishing streamflow and water quality data in the WRB.

### 1.7.2 Hydropower

Federal hydroelectric power facilities are installed at eight of the 13 USACE projects in the WRB. The volume of water flowing over a dam and the change in elevation, known as fall or 'head,' from one point to another determines the amount of available energy in moving water. In general, the greater the water flow and the higher the head (fall), the more electricity a hydropower plant can produce.

Hydropower plants are located at the base of dams. At a hydropower plant, water moving over a dam flows through a pipe, or penstock, and then pushes against and turns blades in a turbine to spin a generator to produce electricity (Figure 1.7-1).

In the WVS, all flow over or past dams is directed through the hydropower plants, or generating facilities, unless there are special circumstances which require the use of another outlet. Special circumstances include operations for downstream fish passage, operational temperature control, turbine power outages, or outflow that exceeds turbine capacity. The locations, dam type, types of generation, and capacities are shown in Figure 1.7-2.

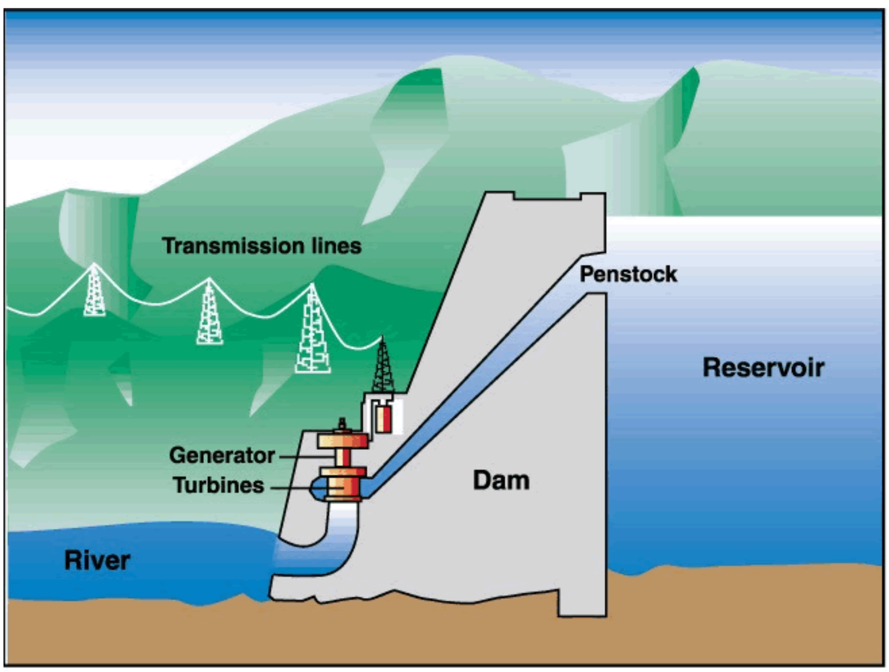


**Figure 1.7-1. Diagram of a Hydropower Dam**

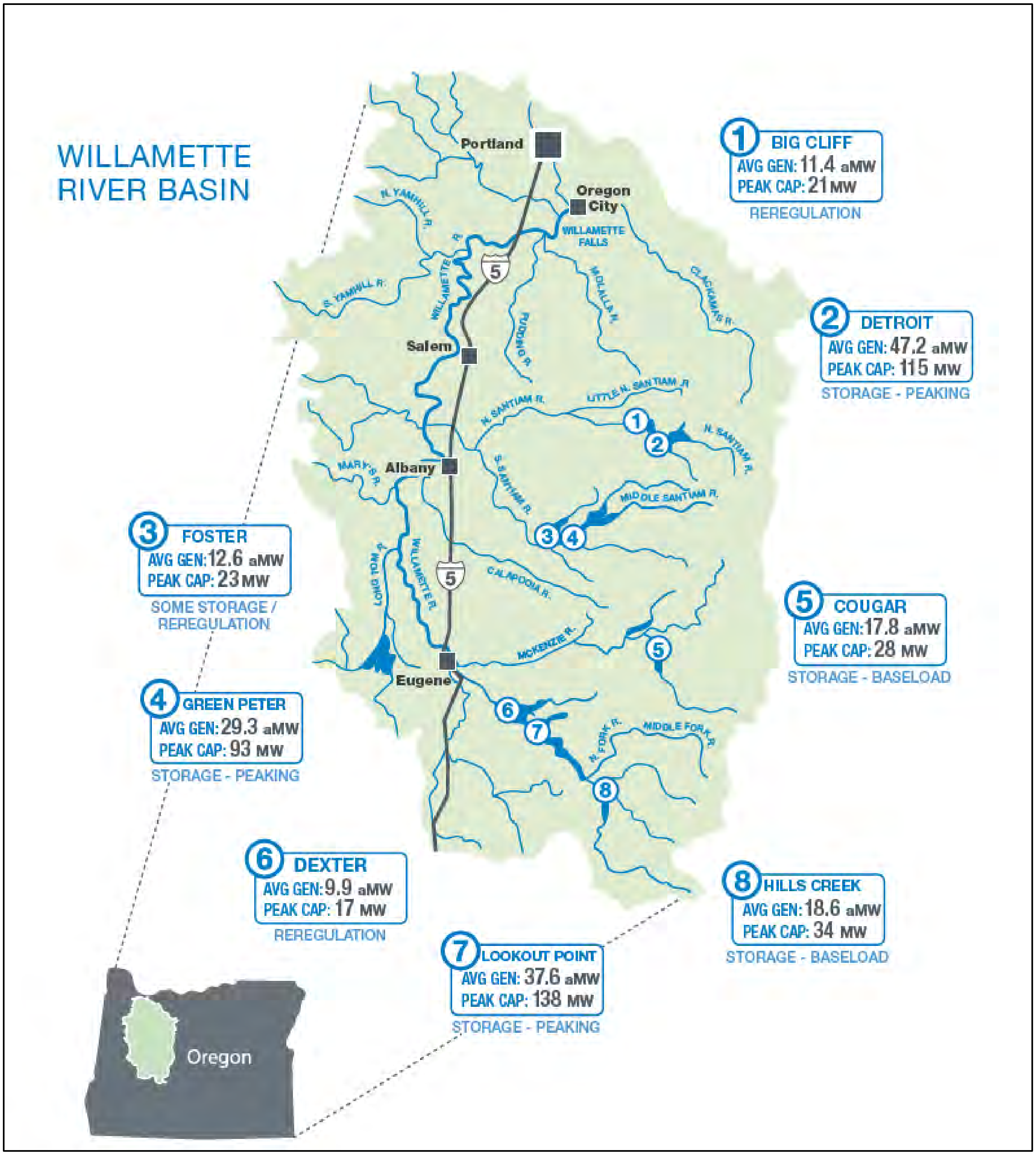


**Figure 1.7-2. Locations, Dam Type, and Capacities of Hydropower Units in the WVS**

Operation of the power transmission facilities (Figure 1.7-3.) at the projects is a highly coordinated effort between USACE and BPA. BPA is a non-profit, federal power marketing administration located in the Pacific Northwest that is responsible for maintaining the safety and reliability of the transmission grid and for marketing the electrical energy generated at the WVS projects (Appendix L).

**Figure 1.7-3. Transmission Lines Exiting Powerhouse at Detroit Dam**

There are two main types of federal hydropower projects in the WVS: storage projects that receive unregulated inflow and reregulation projects that receive and moderate dynamic flows from upstream dams; one dam in the system performs both storage and reregulation functions. Generation from the storage projects is often based upon daily, weekly, and seasonal fluctuations in power demand ("load") and flows downstream are, therefore, subject to fluctuations that require reregulation.

The reregulation reservoirs are used to absorb the fluctuations in flows from their upstream storage projects and ensure that downstream river flows are more uniform for protection of aquatic habitat and human life, and bank stability. Power generation at the combination reregulation projects is uniformly consistent throughout the day.

Lookout Point, Detroit, and Green Peter are storage projects whose outflows are reregulated by dams located downstream: Dexter, Big Cliff, and Foster, respectively. The Foster project also acts as a storage facility because it receives a large portion of unregulated inflow from the South Santiam River along with the controlled flows from Green Peter. The Hills Creek and Cougar storage projects do not have reregulation dams located downstream but do generate hydropower. Dorena Dam has a private hydropower facility regulated by FERC, and power generated is not part of the BPA system. Table 1.7-1, illustrates the average annual power generated at each project.

**Table 1.7-1. Annual Power Production (aMW)**

| Project | Average Annual Generation (aMW) | Peak Cap (MW) |
|---|---|---|
| Big Cliff | 11.4 | 21 |
| Cougar | 17.8 | 28 |
| Detroit | 47.2 | 127.8 |
| Dorena* | 3.2 | 8 |
| Dexter | 9.9 | 17 |
| Foster | 12.6 | 23 |
| Green Peter | 29.3 | 93 |
| Hills Creek | 18.6 | 34 |
| Lookout Point | 37.6 | 138 |
| Total: | **187.6** | **477** |

*Dorena Dam is a privately owned hydropower facility regulated by the Federal Energy Regulatory Commission (FERC).

Hydropower operations are generally flexible and can enable electricity generation to vary with daily and seasonal demand. During the critical power production period from October through March, reservoirs at hydropower facilities have allocated storage space for power generation, called the "power pool." This is water that is stored for when there are generally high demands for electricity. Power pools are managed in accordance with the water control diagrams and plans.

### 1.7.3 Fish and Wildlife

The WVS is operated and maintained in a manner that supports fish and wildlife. Projects provide opportunities for sport fishing and wildlife hunting, improving habitat, and preserving wildlife. Actions can include efforts to restore ecological function, promote species biodiversity, and monitor sensitive species. Operations support habitat within the reservoirs and augment stream flows downstream of dams during dry months. Current specific operations for ESA-listed fish are described under the NAA.

### 1.7.4 Recreation

Recreation use and development is authorized at all the WVS projects. Recreational facilities are provided at all USACE projects and along most of the downstream reaches. USACE cooperates with the USFS, Oregon State Parks, ODFW, and Linn and Lane Counties to build and manage a system of water-related recreation facilities.

Recreational demand in the basin places pressure on maintaining reservoirs at high levels for summer and early fall months. Many boat ramps and marinas become unusable when reservoir levels become abnormally low during the peak recreation season due to drought or other factors.

### 1.7.5 Navigation

Navigation was authorized at most of the projects in the WVS. However, HD531 recognized low channel depths due to increased withdrawal of streamflow as an impediment to navigation upstream of Willamette Falls.

Storing excess spring runoff and releasing this stored water during the low flow season would provide adequate channel depth from Corvallis through the Willamette Falls. However, the upper river above Willamette Falls Locks is no longer utilized by commercial navigation. HD531 noted that the flows released for navigation on the mainstem Willamette River, with flow targets at Albany and Salem[7], would also reduce the pollution concentrations in the river, providing for improved water quality and fish life.

The current minimum flows released per the 2008 NMFS BiOp are at least as high as those noted in HD531. Therefore, the navigation purpose is met by release of water for water quality and biological needs.

### 1.7.6 Municipal and Industrial Water Supply

The Water Supply Act of 1958 (Public Law 85-500) added water supply as an authorized purpose at USACE projects. However, the need for M&I storage was found to be relatively low at the time that the storage capacity of the reservoirs was planned.

The Willamette River and its tributaries are a major source of water for municipal and industrial needs. To date, M&I systems have been developed and rely on natural flow in the WRB. However, population growth is leading to a demand for water that exceeds existing supplies for many M&I systems throughout the basin. This need was one of the factors that led to the WBR Feasibility Study project, which resulted in the reallocation of 159,750 acre-feet from conservation storage to M&I water supply.

To date, there are no agreements for using storage from any of the Willamette project reservoirs for M&I water supply, but there is considerable interest among water suppliers in the WRB. See Section 1.8.2 for additional information on recent conservation pool allocations for water supply.

### 1.7.7 Irrigation

Agriculture is a key trade sector in Oregon, ranking first in volume of exported products and third in value of exported products. About 80 percent of Oregon's agricultural production leaves the state, with about half going to domestic markets and half to international.

AI diversions in the WRB are not centralized. There are eight irrigation districts in the study area; however, most irrigation needs are met via individual wells or diversions. In the WRB,

[7] A flow target is the volume of water intended to be met at a given location. HD531 identifies Albany, Oregon and Salem, Oregon as locations where minimum flows are to be met.

there are more than 18,000 water rights permitted for irrigation uses, representing 65 percent of all authorized water rights.

There are presently no supplemental USACE releases intended specifically for irrigation use except at Detroit and Fern Ridge Reservoirs. Withdrawals associated with BOR's irrigation water service contracts are generally met within normal dam operations and releases.

### 1.7.8 Water Quality

HD531 authorizes the release of water for "stream purification" by diluting pollution levels. Congress anticipated that the water released for navigation purposes would "increase discharges on the upper Willamette River threefold and approximately double present low-water discharges on the lower river" (H.R. DOC. NO. 75-544), diluting pollution levels in the Willamette River. Pollution abatement via dilution was focused on dissolved oxygen, pathogenic bacteria, and solids.

In the 1996 WRDA (Pub. L. No. 104-303) and 1999 WRDA (Pub. L. No. 106-53), Congress authorized the construction of a water temperature control tower at Cougar Dam to manage water temperatures downstream of the dam for the benefit of spring Chinook salmon and native trout, including bull trout, which were listed as threatened under the ESA in 1999.

## 1.8 SYSTEM OPERATION AND ANNUAL OPERATIONAL PLANNING

Operation of the WVS generally follows a seasonal cycle and is dynamically managed to meet several related, but sometimes conflicting, objectives. These objectives include providing adequate flood storage space for managing floods downstream; providing sufficient water levels for water quality, recreation, and fish and wildlife; providing adequate water releases for water quality and fish and wildlife; providing adequate water supply for irrigation and M&I uses; and maximizing power generation within the requirements imposed by other objectives.

The four-season cycle that is generally followed includes the winter FRM season, spring refill, summer conservation season, and fall release; these seasons are graphically represented in Figure 1.8-1.

Table 1.8-1 highlights reservoir water control operations in each month. Note that the exact timeline can shift depending on the project and season. Operations can occur simultaneously, such as outflow reduction and conservation pool refill to maximum, which both occur during the spring refill season.

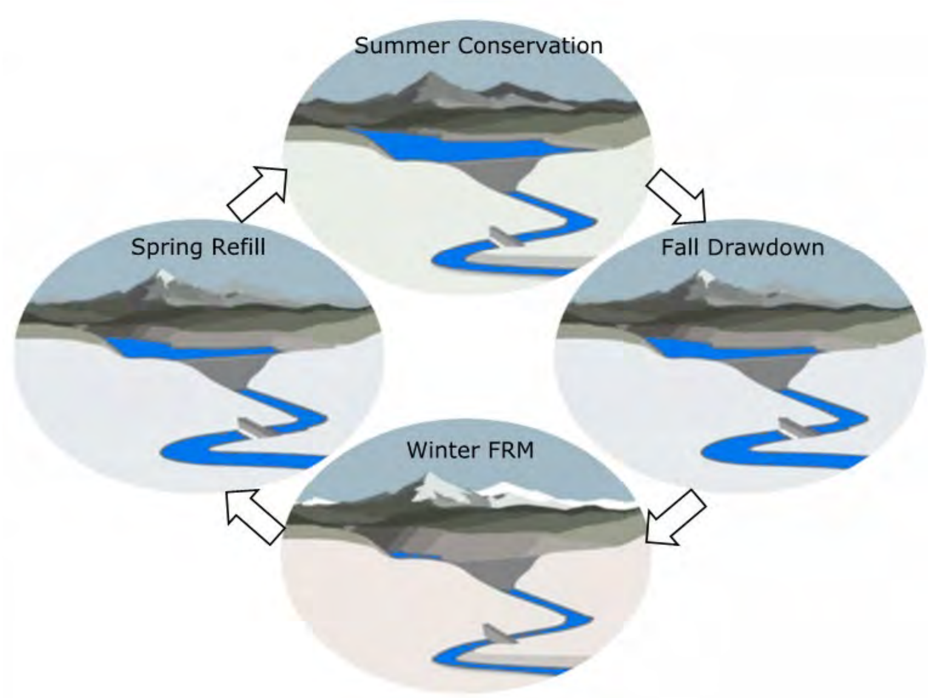


**Figure 1.8-1. Seasonal Operations of the Willamette Valley System**

**Table 1.8-1. Generic Reservoir Water Control Operations by Month**

| Months | Operation | Description |
|---|---|---|
| November - January | Winter Flood Risk Management Season | Projects maintained near minimum conservation pool elevations. During storm events, inflows are retained, and water is released downstream to minimize flooding effects. |
| February - May | Spring Conservation Pool Refill | Refill of the reservoirs according to the water control diagram during the conservation season is largely dependent on rain events, but maximum conservation pool is generally reached from mid-April to mid-May. |
| April - November | Summer Conservation Season | Inflow is gradually stored in reservoirs and later used for purposes such as irrigation, water supply, recreation, power production, and meeting minimum flows for fish and wildlife. |
| September - November | Fall Reservoir Release | USACE begins releasing water from all storage reservoirs to meet the authorized conservation season purposes and regain capacity for FRM. The reservoirs are drafted to their minimum conservation pool to achieve their full FRM potential by about the end of November. |

Operating the WVS to meet multiple purposes is in part made possible by releasing water through outlets located at various depths in each dam. When a WVS dam sufficient stored water, surface water can be released over the spillway.

Spillways are structures that either form part of a dam or are found just beside it. These outlets pass floodwater safely, and in a controlled way, over a dam, around it or through it. Many WVS dam have spillways with gates that allow operators to control flow over the spillway anytime the reservoir is high enough for other reasons than just flood control such as for fish passage and downstream temperature management. Once the reservoir water elevation goes below the operational elevation of the spillway this outlet is no longer available for releasing water.

Water is also released through the regulating outlets (ROs) located at a lower elevation on the dam, deeper in the reservoir. These consist of pipes, box culverts, or tunnels with gates or valves to regulate the flow rate.

Hydropower dams have an additional outlet, the penstock, that directs water through the turbines to produce power. A basic outlet configuration for a hydropower dam is presented graphically in **Error! Reference source not found.** below.

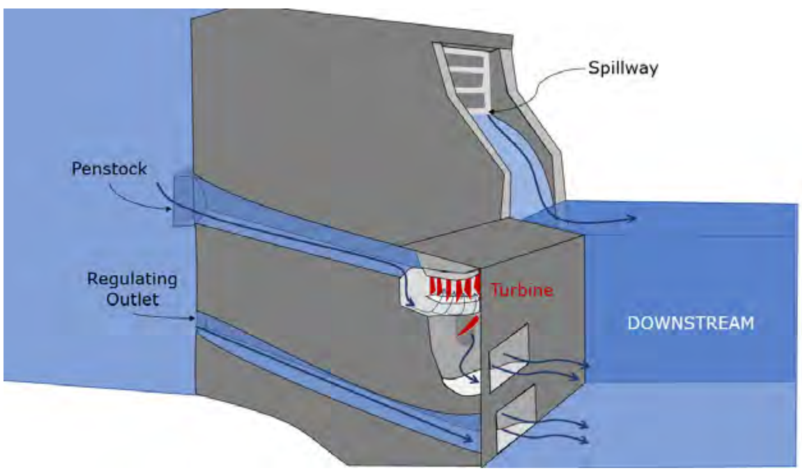


**Figure 1.8-2. Basic graphical representation of a hydropower dam outlet configuration**

The multiple outlets and USACE operational procedures allow some flexibility in WVS operations as USACE attempts to meet the diverse and changing needs of the region based on information that becomes available over the course of the operating year. Many factors cause short-term operational adjustments. For example, sometimes periods of heavy rain cause higher flows in the fall. In a dry year, minimum fish flows and other constraints dictate how much water the projects must discharge.

The actual operations take place in what is described as “real time,” that is, decisions must be made in a few minutes, days, or at most, a few weeks. Operators regulate the system to satisfy all the various purposes contained in the annual operating plan. In-stream conditions for fish, generator outages, the weather, and even the timing of recreational events can influence operational decisions. There are also periodic maintenance activities that affect reservoir levels.

The general procedures for reservoir elevation and water control, as well as the annual system operation processes and activities, are described in this section.

### 1.8.1 Reservoir Pools and Water Control

Overall, reservoir water storage capacity can be conceptualized as a series of layered pools making up the overall reservoir pool. The pools can indicate designated purposes or management targets and occupy elevation bands that shift by season or specific operating conditions.

A typical WVS reservoir would include maximum, conservation, flood, power if it is a power producing project or an inactive pool if it is not power producing, and a dead pool (located below any outlets which makes water in this area inaccessible for release through the dam). These pools may change throughout the year and are presented graphically in **Error! Reference source not found.** below.

The maximum pool is the maximum level to which the reservoir surface is allowed to rise during normal operating conditions. The conservation pool storage is allocated for M&I, AI, fish and wildlife, but supports water quality and recreation. The conservation pool may overlap some of the same elevation bands as the flood pool, but the maximum conservation pool does not rise to the elevation of the overall reservoir maximum pool.

The flood pool contains space that is used during storm events to retain flood waters to reduce downstream risks. The flood pool has further designated minimum, summer, primary, and secondary pools that pertain to different management conditions. The summer flood storage pool is the space above the maximum conservation pool up to the reservoir maximum pool. When this pool is filled, it is called full pool.

The power storage pool lies below the conservation and flood pools. It contains water used for the generation of hydroelectric power and has designated maximum and minimum pools. The inactive pool is designed to trap sediment and is the lowest storage area in a reservoir.

To manage for the different purposes and seasonal needs, USACE utilizes water control diagrams. Individual water control diagrams depict the allocated pools and elevations, also known as water-year-based rule curves, over the course of a year for each project. **Error! Reference source not found.** is a typical water control diagram that indicates the general trends throughout the year and vary by project. These water control diagrams are contained in the water control manuals for each individual project, along with detailed operations and procedures. The draft Master Water Control Manual integrates the operation of the individual dams and reservoirs to meet the system-wide goals of the WVS (Section 1.7).

All projects with hydropower facilities include storage space designated for power generation during the critical power period from October to March. This storage is relatively small and is between minimum conservation pool and minimum power pool elevations (Figure 1.8-3). The power pool is generally kept full to increase the hydraulic head, defined as the potential energy of water due to its height above the bottom of the dam, for power generation.

Departures from the rule curves (storage targets) during reservoir refill may be necessary due to the need for regulation of floods, excessive snowpack above the reservoirs, inadequate water supply, or critical power needs. Refill can be delayed when high runoff is expected, as this provides additional storage for flood damage reduction operations. Generally, each reservoir may fill at a rate no faster than shown in the rule curve unless the reservoir is being managed for downstream floods.

Excess flood water stored above the rule curve during the conservation storage season is released targeting discharges at or below downstream channel capacity. During dry conditions, the reservoir may be higher than the rule curve to reduce the risk of not filling the reservoir. When the water supply is inadequate to maintain both minimum flows and the scheduled rate of filling, maintaining minimum in-stream flows downstream of a dam generally takes precedence, per the 2008 NMFS BiOp.

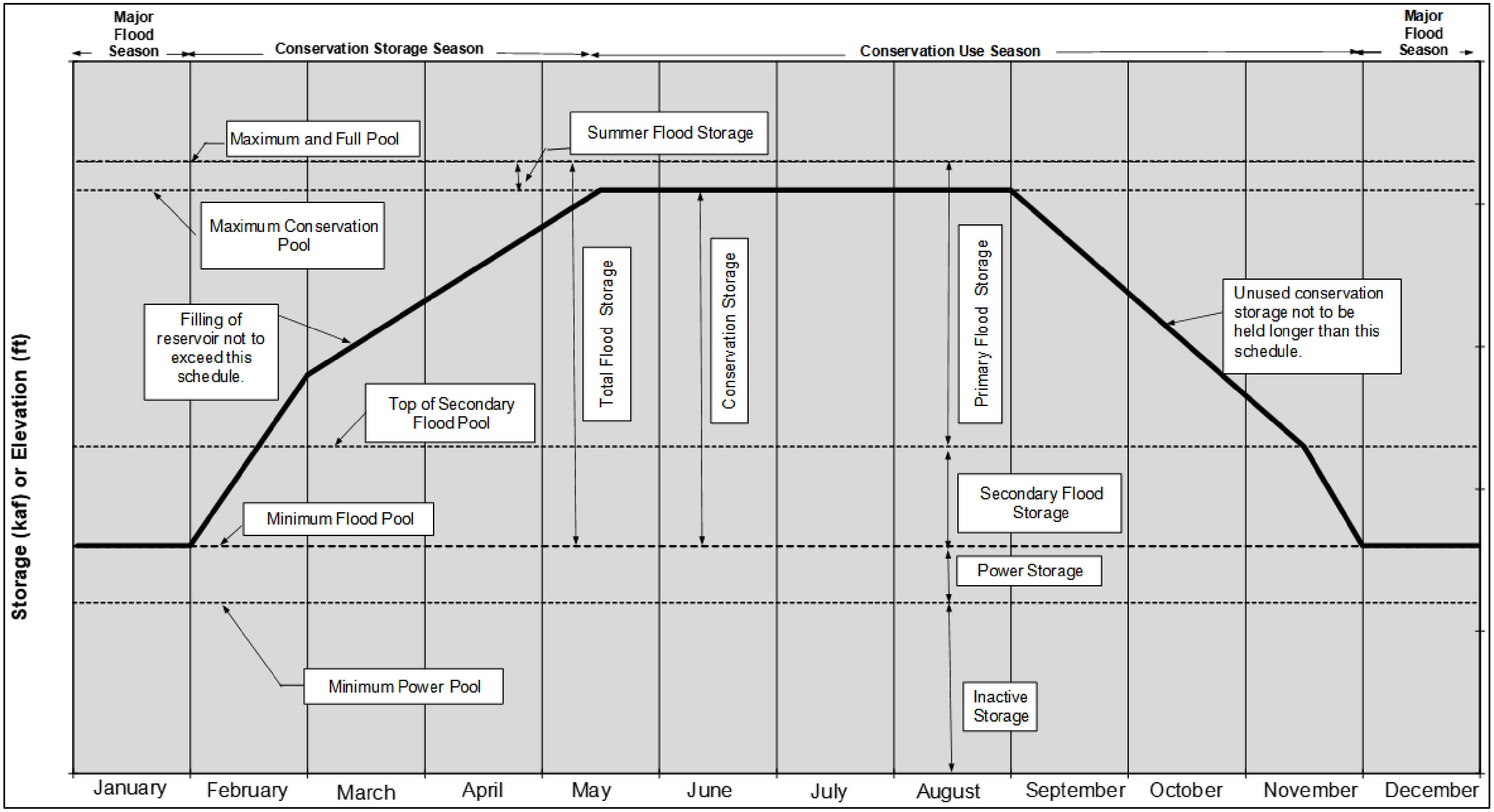


**Figure 1.8-3. Typical Water Control Diagram for WVS Dams and Reservoirs**

### 1.8.2 Conservation Pool Allocation

USACE and OWRD recently completed the WBR Feasibility Study (discussed in Appendix L) to examine current and projected water needs and demands in the WRB for fish and wildlife, M&I water supply, and AI. The WBR Feasibility Study Chief's Report[8] was signed in December 2019.

In December 2020, Congress authorized the substantial reallocation of the conservation storage space in the WVS reservoirs for three purposes: fish and wildlife, M&I water supply, and AI in accordance with the Chief's Report. The conservation pool storage was divided as shown in Table 1.8-2.

**Table 1.8-2. Authorized Use Allocation of Combined Conservation Storage**

| Purpose | Acre-feet of Combined Storage Space |
|---|---|
| Fish and Wildlife | 1,102,600 |
| Agricultural Irrigation (AI) | 327,650 |
| Municipal and Industrial (M&I) Water Supply | 159,750 |

The allocations were based on a forecasted peak water demand in the year 2070, following the 50-year planning horizon of the feasibility study. Because USACE incorporated a 30-year planning horizon for this PEIS, the demand for M&I water supply and AI was calculated to the year 2050.

In 2019, NMFS issued a jeopardy BiOp for the WBR (NMFS, 2019). The RPA measure 2 of the 2019 NMFS BiOp for the WBR includes a cap on new water storage for M&I use at 11,000 total acre-feet until certain conditions were met. It further restricted USACE from executing any agreements in the Santiam Basin until NMFS issued a written statement that instream water rights are in place and providing sufficient protection to flows intended to benefit fish. USACE determined it is reasonable to assume this cap would be lifted in the future, allowing USACE to enter into agreements for the full allocation, which is projected to occur over the next 50 years.

AI was anticipated to be a significant use of water stored in the project reservoirs when the WVS was first authorized by Congress. BOR administers water service contracts for irrigators within 15 water service contract reaches. Irrigation use from the WVS reservoirs in the WRB has not increased as initially projected and is not expected to increase in the future at levels near the scope and scale originally envisioned. As of October 2022, there were 266 BOR Water Service Contracts for 82,815 acre-feet of water per year (approximately 5 percent of the conservation storage).

[8] A Chief's Report is a report from the USACE Chief of Engineers developed when a water resources project would require Congressional authorization - or a change to existing project authorization. After the final feasibility report is submitted to USACE headquarters, a Chief's Report is developed.

At the current low level of use for water service contracts, USACE does not make special operational adjustments, such as increasing flow releases, to meet contract requirements at most projects, except for Fern Ridge and Detroit. However, in deficit water years, the 2008 NMFS RPA requires BOR to curtail water contract diversions. In other years, the RPA requires USACE to release more than minimum flow to ensure the contract users do not take water intended for fish purposes from Fern Ridge and Detroit. In “deficit" water years, as defined in the 2008 NMFS BiOp, a partial water supply or no water supply may be available to satisfy some existing and new irrigation contracts. Water deliveries may be ceased or curtailed under these conditions, per RPA 3.4. (NMFS, 2008).

### 1.8.3 Water Control Annual Planning

Operational planning for the conservation release season begins with the January water supply forecast and continues through October[9]. The conservation season is approximately from April through October but can extend through November when the minimum conservation pool is reached, including the spring filling season and the summer conservation season. Forecasts are required during the conservation storage period to assess the timing and capability of refilling to the desired maximum conservation storage elevation of individual projects.

Forecasts during this period are needed to maintain spring mainstem flows based on the minimum flow objectives for ESA-listed species included in the 2008 NMFS BiOp. A document titled *Willamette Basin Project Conservation Release Season Operating Plan* (Conservation Plan) is prepared annually to provide flow requirements based on the basin water supply for that year. The Conservation Plan identifies flow and storage needs for each tributary and USACE reservoir in the WVS and mainstem Willamette control points based on the anticipated total system storage in mid-May from the April forecast. Flow requirements in the Conservation Plan are consistent with flow targets outlined in the 2008 NMFS BiOp.

The hydrology of the Willamette Basin is not conducive to long-range runoff forecasting for daily reservoir regulation purposes. A major portion of the runoff during November through March occurs as a direct result of rainfall. Detailed forecasts are not quantitatively predictable beyond 24 to 48 hours.

While climate information is being produced by the NOAA Climatic Data Center, long-range streamflow forecasts beyond those required for the conservation release season described are not used for the WVS since all projects operate on a fixed rule curve that requires the reservoirs to be at minimum conservation pool during the winter flood season, and then to refill during the spring.

A Drought Contingency Plan provides a plan of action if a potential drought situation were to occur. Like the long-range forecasts, drought forecasts beyond those required for the conservation release season are not used for regulation of the WVS since all projects operate

[9] The information presented in this section has been adapted from the Master Water Control Manual for the Willamette Valley Project (2015).

on individual, fixed, rule curves. Prediction of winter/spring droughts is nearly impossible due to the variability of our regional weather systems.

### 1.8.4 Streamflow and Water Quality

WVS dams were designed and constructed to modify, control, and regulate the streamflow characteristics of their tributaries and the mainstem Willamette River. In general, WVS operations have resulted in higher flows in the summer and reduced peak flows in the winter than historical flows. These hydrologic effects modify fish habitat characteristics in the downstream reaches.

WVS is operated in a manner that helps mitigate adverse effects of the projects, including maintenance of flows downstream of the projects and in the mainstem of the Willamette River. Augmenting downstream mainstem Willamette flows at Albany and Salem is important for water quality and fish and wildlife purposes.

The 2008 BiOps require USACE to release flows at WVS dams to achieve streamflow minimums in the tributaries and mainstem Willamette throughout the year and to stay below maximum flows during key spawning periods in the tributaries. Mainstem minimum flow targets for adequate and abundant water years are listed in Table 2.2-4, and the tributary minimum and maximum flow targets are provided in Table 2.2-3 in the NAA description provided in Section 2.4.11. Additionally, the 2008 BiOps established ramping rates that dictate how quickly flows are increased or decreased. USACE strives to adhere to the established ramping rates except during emergencies and flood control operations. The flow targets and ramping rates are described in the 2008 NMFS BiOp RPA measures 2.2 to 2.6.

Streamflow augmentations increase flows during the low water period and benefit sanitary conditions along the mainstem by diluting pollution, moderating extreme temperatures, and increasing the dissolved oxygen content of WRB streams, resulting in a beneficial effect on fish and wildlife. Flow targets and ramping rate requirements discussed above and provided in Section 2.4.1.1 aid in achieving consistency with the 2008 BiOps.

Water quality management objectives in the WVS include control of instream water temperature and reduction in Total Dissolved Gas (TDG) concentrations in river reaches below dams. Details on operations to address temperature targets and TDG are described in the NAA under Sections 2.4.1.2.1 and 2.4.1.2.2.

### 1.8.5 Operational Considerations for Hydropower

USACE performs ongoing, coordinated water management actions at the dams to increase or decrease electricity generation in response to the needs of the federal transmission system. These needs include management of operating reserves and the accommodation of planned or emergency transmission line outages.

At times project releases are limited by different constraints like ESA requirements. Operational changes are coordinated with the Services if they deviate from criteria in the 2008 BiOps during non-flood operations. In emergency situations and in managing the system to avoid emergencies, power system operations would be prioritized to protect human health and safety as well as the safety and reliability of the power grid.

### 1.8.6 Operational Considerations for Recreation

Recreational facilities are provided at all USACE projects. Recreational demand in the basin puts pressure on maintaining reservoirs near maximum conservation pool for the entire recreational season. A drawdown priority for the projects to meet tributary and mainstem flow targets continues to evolve over time given hydrologic conditions and in-stream biological needs. Detroit, Fern Ridge, Cottage Grove, Dorena, and Foster Reservoirs have been identified as having the highest recreational demand within the WVS, and all but Detroit lack the capacity to significantly augment mainstem flows. These are the last reservoirs to be drawn down to meet flow requirements on the mainstem of the Willamette River, as measured at Albany and Salem.

The conservation pools at these reservoirs are typically maintained at as high an elevation as possible until early September, and projects with lower recreation demand are used first for meeting summer flow requirements at Albany and Salem.

Additional information on USACE management of recreational facilities can be found in Section 1.9.

### 1.8.7 Environmental Flows

Dam releases that benefit downstream ecosystem health are termed environmental flows, or e-flows. E-flow targets were developed through a process of collecting and synthesizing relevant hydrologic and ecological information and expert knowledge into a set of flow recommendations, summarized in a USACE Memorandum for the Record, dated July 17, 2015 (USACE, 2015l).

E-flow implementation has been developed by USACE in coordination with The Nature Conservancy at multiple projects within the WRB. The implementation of e-flows is event-driven, meaning they are based on regulator/operator judgement. Maximizing e-flows is valuable to efficiently manage aquatic habitats as it creates both opportunities for, and the means to manage, fish spawning, incubation, and other habitat needs. Fish populations and other aquatic organisms are adapted to these variable flow conditions.

Each seasonal flow contributes to some aspect of ecosystem health. Fall flows occur from October to November, winter high flows occur from November to February, and smaller spring flows occur from March to June. E-flows recommendations have been developed for the Middle Fork Willamette River, McKenzie River, and the North, South, and mainstem Santiam Rivers. Flow recommendations are defined by event duration, number of events per year, range of flow magnitude, and frequency.

E-flow operations are governed by the Water Control Manual operational requirements for each project and the 2008 NMFS BiOp. The general intent is to maximize opportunities for achieving e-flows while considering operational constraints and forecast uncertainty. E-flow operations require the use of stored water to achieve environmental goals. This can be particularly difficult to achieve during hydrologically and meteorologically dry water years.

### 1.8.8 Operation, Maintenance, Repair, Replacement, and Rehabilitation

After a water resources project is constructed, the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) phase begins. During this phase, ongoing activities are conducted to support the function of a project.

The OMRR&R phase includes a spectrum of activities that range from regular maintenance activities, such as the repainting a rusty guardrail or replacement of lightbulbs, to major maintenance and rehabilitation activities such as the repair, replacement, or rehabilitation of entire facility components (e.g., the replacement of the slide gate seals or repair of hydraulics in a dam). OMRR&R activities occur at all facilities in the WVS including within and around the dams and powerhouses, the adult fish facilities, and the hatcheries.

This section describes the distinction between regular and major operation, maintenance, repair, replacement, and rehabilitation and outlines how activities under each are addressed in this PEIS.

#### *1.8.8.1 Scheduled/Routine Maintenance*

Routine maintenance is defined as the maintenance, repair, or replacement of existing fixtures or parts in which no changes are made to original design or purpose, to ensure that WVS facilities run safely. Routine maintenance includes those activities that are predictable and repetitive, but not those that would constitute major repairs or rehabilitation of a capital asset. This type of preventative and corrective maintenance is coordinated and planned to occur at regular intervals and is also referred to as scheduled maintenance.

Routine maintenance is performed on all WVS hatcheries, fish facilities, spillway components, generating units, and supporting systems to ensure project reliability and to comply with federal regulatory requirements. Routine maintenance is coordinated through a regional forum, such as the Willamette Fish Passage Operations & Maintenance[10] (WFPOM) and WATER (Section 1.8.8), to minimize effects to ESA-listed fish species by designating in-water-work-windows and other construction constraints.

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[10] The Willamette Fish Passage Operations and Maintenance (WFPOM) forum develops recommendations for ongoing operations and maintenance activities that may affect listed fish species. This forum also includes technical discussions relating to hatchery programs. This forum is responsible for providing input on annual changes to the Willamette Fish Operations Plan, which dictates how facilities must operate to minimize impacts to ESA-listed species.

The routine maintenance program allows staff at USACE, BOR, and BPA to proactively plan and schedule capital improvement programs based on equipment condition and degradation to ensure system operations remain safe, reliable, and in compliance with applicable laws and regulations.

These activities are described in the Operations and Maintenance Manuals for each facility. The library of Operations and Maintenance Manuals is incorporated here by reference; Appendix A provides an annotated bibliography of these manuals.

#### *1.8.8.2 Unscheduled and Non-routine Maintenance*

Unscheduled maintenance is reactive maintenance that addresses issues as they arise. It can occur any time there is a problem, unforeseen maintenance issue, or emergency that requires a project feature, such as a generating unit, be taken offline to resolve the problem. The timing, duration, and extent of these events are unforeseeable. Unscheduled maintenance events are coordinated through the appropriate teams under a regional forum, such as the WFPOM and WATER, to minimize negative effects on fish.

Non-routine maintenance is proactively planned but not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations). Non-routine maintenance includes tasks that may be more imperative in nature than routine maintenance and these tasks may or may not constitute major maintenance and rehabilitation.

Major maintenance and major rehabilitation are defined in Engineering Circular 11-2-222. Major maintenance is defined as a non-repetitive item of work or aggregate items of related work for which the total estimated cost exceeds the limit set forth by Engineering Circular 11-2-222, and that does not qualify as major rehabilitation.

Major rehabilitation is defined as structural modifications to restore or ensure continuation of an existing facility's functions or outputs. This does not include normal maintenance of existing capabilities or prevention of deterioration. Examples of non-routine maintenance include power plant modernization and major upgrades of project features.

Non-routine maintenance and major maintenance and rehabilitation may be considered major federal actions. Each action would be assessed for environmental compliance prior to implementation and may be subject to NEPA review.

### 1.8.9 Coordination of WVS Operations with Other Agencies

USACE is ultimately responsible for the O&M of the WVS. However, USACE also coordinates with or collects input from regional stakeholders such as NMFS, BPA, USFWS, USFS, tribes, ODFW, ODEQ, Northwest Power and Conservation Council, and other partners on operations and natural conditions that may affect their interests. WATER, a collaborative advisory body made up of USACE, other federal and state agencies with fisheries and water resource management responsibilities in the WRB, and affected tribes, was established under the 2008

BiOps to coordinate with USACE on operation of the WVS. One forum for this coordination is the WFPOM team, which annually develops the Willamette Fish Operation Plan (WFOP).

The WFOP describes year-round O&M activities at USACE WVS projects to protect and enhance ESA-listed fish species as well as non-listed species of concern. The WFOP guides USACE actions related to fish protection and passage at the 13 WVS dams. Other USACE documents and agreements related to fish passage at these projects are consistent with the WFOP.

Although USACE is the final decisionmaker on all water management decisions in the WVS, USACE also considers input from regional stakeholders through a forum known as the Flow Management and Water Quality Team (FMWQT). The FMWQT is a technical team organized under WATER. The FMWQT meets monthly to provide flow forecast updates and gather input on decisions related to flow management. Special operations related to fish protection and passage identified in the WFOP are coordinated through the FMWQT.

## 1.9 ONGOING USACE PLANNING AND ENVIRONMENTAL REVIEWS IN THE REGION

In addition to the PEIS, USACE has several other ongoing environmental review efforts in the WRB. These reviews are either not directly related to long-term operation and maintenance of the WVS or ESA compliance, involve nonfederal sponsors, do not rise to the level of a programmatic NEPA document, or have insufficient information to be considered as related to the scope of the PEIS. Some of these reviews involve reasonably foreseeable future actions and are described in Chapter 4. Details about each of these ongoing reviews are provided below.

### 1.9.1 Master Plans

USACE is currently undertaking a multi-year effort to revise six Master Plans for USACE-managed lands withing the WVS grouped by sub-basin. These Master Plans would replace the outdated, existing individual and regional Master Plans.

A Master Plan is a strategic land use management document that guides the comprehensive management and development of all recreational, natural, and cultural resources throughout the life of a USACE Civil Works project. Master Plans are required for USACE Civil Works projects, which are administered by USACE for management of natural and manmade resources.

The Master Plans cover many resources, including but not limited to water, fish and wildlife, vegetation, cultural, aesthetic, interpretive, recreational, and mineral. The Master Plans do not address operations for flood risk management, water quality, water supply, hydropower, navigation, fish and wildlife, recreation, or maintenance the dams and fish facilities.

The process of updating Master Plans encompasses interrelated tasks involving the review and analyses of environmental, recreational, and socioeconomic trends within a generalized conceptual framework. This framework includes regional and ecosystem needs, project resource capabilities and suitability, expressed public interests that are compatible with project authorized purposes, and environmental sustainability elements. USACE must ensure that Master Plan revisions reflect equal attention to the economy, the environment, and effective management of project resources and facilities at the appropriate scale. The six Master Plans and their associated programmatic NEPA documents shall be prepared in accordance with and include the requirements of all laws, regulations, guidance, and polices.

### 1.9.2 Interim Risk Reduction Measures

USACE is continuously assessing its dams as part of its comprehensive dam safety program to better understand dam safety risks and inform future actions. The USACE Dam Safety Program periodically assesses and reassesses risks to all WVS dams on a 5-year cycle.

When risks are identified, there is a process for elevating them for more detailed analysis and design to ensure risks are adequately addressed. The assessment process identifies and analyzes many risks using the latest science and engineering methods and standards. This process is described in more detail in Appendix H.

Many of the risks analyzed are often not consequential or probable enough to merit further action. However, in 2020, after completing a detailed analysis of the seismic risk at Detroit and Lookout Point Dams, it was concluded that immediate action to mitigate the risk at these dams was necessary.

Per Engineering Regulation, ER 1110-2-1156 (USACE Publications), "USACE has specific public safety responsibility, when a project has known safety issues, to take appropriate interim risk reduction measures including reservoir releases. USACE statutory responsibilities require operation of dams in a manner that reduces the project's probabilities of failure when there are known issues with the integrity of the project."

This determination resulted in development of Interim Risk Reduction Measures (IRRM) to address these risks until a permanent solution could be assessed and designed. IRRMs at these dams required pool restriction on the maximum pool elevation. In other words, the maximum elevation the associated reservoirs are allowed to reach each summer is lower than the authorized maximum identified in the water control manuals.

The USACE Portland District is engaged in dam safety studies for the remaining dams in the basin. Additional dam safety IRRMs may be recommended at different projects. Those actions will have site-specific environmental compliance including NEPA reviews.

### 1.9.3 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*[11]*.* The order directed USACE to implement injunctive actions intended to improve conditions for fish passage and water quality in the WVS to avoid irreparable harm to

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[11] 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).

ESA-listed salmonids until the completion of the reinitiated ESA Section 7 consultation with NMFS. The Court ordered operations will continue until consultation concludes.

Additionally, the Court ordered operational changes and three structural modifications to existing projects. The three structural modification projects 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. As the direct and indirect effects of these projects will be fully assessed by their individual NEPA documents, they are not included in Chapter 3 of this draft PEIS. However, as ongoing environmental reviews within the WRB, Chapter 4 includes the operation and maintenance of these ongoing and future projects in the cumulative effects analysis. A description of the three Court-ordered projects is provided in Table 1.9-1.

**Table 1.9-1. Court-ordered Structural Improvements**

| Dam | Description | Status |
|---|---|---|
| Dexter | Design and construct upgrades to the Dexter adult fish facility. | Design is underway with a schedule to start construction in Summer of 2023. |
| Big Cliff | Determine whether operational measures alone 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. | The Corps determined that operational fixes are not sufficient and developed a schedule for design and construction of TDG abatement at Big Cliff Dam. |
| Cougar | Determine whether structural improvements/modifications need to be made to Cougar Dam's ROs to ensure safer fish passage and reduce total dissolved gas levels and, if so, design and construct a structural solution. | The Expert Panel recommended resurfacing of the RO chute by 30 September 2023 and an alternatives study to be completed by 30 June 2023. |

### 1.9.4 Fern Ridge Vegetation Management Plan

USACE is evaluating whether to expand vegetation management practices utilized at Fern Ridge Reservoir throughout the rest of USACE-operated lands within the WRB. These practices include prescribed burning, mechanical and manual control, herbicide applications, and seed collection and plant propagation, which are intended to improve and maintain diverse native plant communities while preventing, eliminating, or reducing the presence or spread of invasive, noxious, and nuisance plants. A site-specific NEPA Environmental Assessment is currently ongoing for this project.

### 1.9.5 Dexter Shoreline Management

The existing Dexter Shoreline Management Plan is being reviewed to determine necessary revisions to the Plan, including real estate license requirements. The Shoreline Master Plan addresses the rules and regulations, shoreline allocations, and USACE requirements for permitting shoreline use facilities, activities, or development.

Within some of the designated land use areas, USACE plans to issue permits and real estate licenses to private landowners to construct new docks, modify or maintain existing docks, modify vegetation, and construct upland support structures so long as these activities are consistent with a revised Shoreline Master Plan. A site-specific NEPA Environmental Assessment is currently ongoing for this project.

### 1.9.6 Long Tom River Ecosystem Restoration Project

The City of Monroe and Confederated Tribes of Siletz Indians, along with the partnership of the Long Tom Watershed Council, are collaborating with USACE to advance an ecosystem restoration project on the Long Tom River, under USACE's Continuing Authority Program Section 1135, Project Modifications for Improvement of the Environment for ecosystem restoration (WRDA, 1986). This group recognizes that the Long Tom River is a vital watershed for its potential high-quality juvenile salmon rearing habitat, as well as spawning and rearing habitat for cutthroat trout, lamprey, and other native species.

Prior to construction of the Fern Ridge Dam, the lower Long Tom River was a low-gradient river characterized by a narrow channel with high sinuosity. After completion of the dam, the downstream reaches of the Long Tom lacked the channel capacity to convey routine water releases from the reservoir. In 1943, USACE implemented a project resulting in construction of a straighter, deeper, and wider channel with a series of seven drop structures. These drop structures were built with the intent to reduce channel velocities and to decrease erosion.

A drop structure, also known as a grade control, sill, or weir, is a manmade structure, typically small and built on minor streams, to pass water to a lower elevation while controlling the energy and velocity of the water as it passes over. Unlike most dams, drop structures are usually not built for water impoundment, diversion, or to raise a water level. They are mostly built on watercourses with steep gradients to serve other purposes such as water oxygenation and erosion prevention.

While effective at helping to maintain channel stability, drop structures create barriers to fish passage. According to NMFS West Coast Region's Anadromous Salmonid Passage Design Manual, "Drop structure barriers involve a combination of local hydraulic conditions downstream of a barrier and the swimming capabilities of the species and life stage to block migration (Powers and Orsborn, 1985). They create hydraulic conditions that exceed the swimming or leaping capabilities of the fish to overcome the hydraulic condition. Examples include velocity barriers, vertical drop barriers, and velocity drop barriers" (NMFS, 2022).

A site-specific NEPA Environmental Assessment is currently ongoing for this project.

# CHAPTER 2 - ALTERNATIVES DEVELOPMENT AND EVALUATION

Federal agencies must consider all reasonable alternatives to a proposed action (40 CFR § 1502.14). Alternatives must be presented in comparative form, sharply defining the issues and providing a clear basis for choosing among alternatives. The federal agency responsible for this PEIS is USACE, Portland District. As the lead agency, USACE must:

1. Evaluate reasonable alternatives to the proposed action, and, for alternatives that the agency eliminated from detailed study, briefly discuss the reasons for their elimination.
2. Discuss each alternative considered in detail, including the proposed action, so that reviewers may evaluate their comparative merits.
3. Include a No Action Alternative (NAA).
4. Identify the agency's preferred alternative, if one exists.
5. Include appropriate mitigation measures not already included in the proposed action or alternatives.

As described in Section 1.1.1.1, this is a programmatic NEPA review. As such, the range of reasonable alternatives was assessed in consideration of the USACE objective to meet the purpose of and need for the programmatic proposed action and to consider public, external agency, and tribal input.

**Proposed Action**

The proposed action is continued operation and maintenance of the WVS for specific, authorized purposes and in compliance with the ESA and all other applicable treaties, laws, and regulations.

**Purpose and Need**

The purpose of and need for the proposed action is to ensure (1) USACE manages the WVS for its authorized purposes as required by Congress while (2) also meeting its requirements under the ESA (Chapter 1.0). Management of the WVS for its authorized purposes necessitates ongoing and future operation of the system and maintenance at any given project that responds to changes in WRB conditions and new information related to system operations and technology, the affected environment, polices, and regulations such as the ESA.

## 1. Summary of Authorized Purposes Specific to the Proposed Action and Purpose and Need

Details of the purposes for each project within the WVS are provided in Section 1.7. As a summary, the various purposes of the WVS were authorized by Congress in the Flood Control Acts (FCA) between 1938 and 1962, the Water Supply Act of 1958, and the Water Resources

Development Act of 1986. In these acts Congress designated the purpose for each project, which can include a combination of the following:

- flood control (more commonly referred to today as flood risk management (FRM))
- hydropower
- fish and wildlife
- recreation
- navigation
- irrigation (referred to as agricultural irrigation (AI))
- municipal and industrial (M&I) water supply
- water quality

**2. Summary of ESA Requirements Specific to the Proposed Action and Purpose and Need**

USACE must operate and maintain the WVS for specific project 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 Services (Section 1.1.2). As such, an alternative was only considered to be reasonable and carried forward for detailed analyses if these ESA requirements could be met.

Listed species affected by the WVS O&M in the analysis area are bull trout (listed as threatened in 1998), UWR spring Chinook salmon (listed as threatened in 1999), and UWR winter steelhead (also listed as threatened in 1999) (Section 1.1.2).

Dams along the Willamette River and its tributaries block access to substantial portions of spawning and rearing habitat for these listed species and degrade remaining downstream riverine habitats (NMFS, 2008; USFWS, 2008). Fish passage is believed to be a limiting factor affecting the prospects of recovery for ESA-listed and other native migratory fish and include (NMFS, 2008[12]) both the passage of adults migrating upstream to spawn, and juveniles (smolts) migrating downstream toward the ocean. Altered water temperatures and flows also contribute to adverse impacts on bull trout, UWR spring Chinook salmon, and UWR winter steelhead and their habitats (NMFS, 2008[13]; USFWS, 2008[14]).

As described in Section 1.1.2, several ESUs of UWR spring Chinook salmon and UWR winter steelhead are listed as federally threatened or endangered (NWFSC, 2015). Improvements to fish passage and water quality are necessary to comply with the ESA for listed fish and listed salmonid ESUs (Section 1.1.2, Section 1.7.7, Section 1.8.3).

[12] In NMFS, 2008, Subsection 3.2.1.4.3, Multipurpose Dams
[13] In NMFS, 2008, Subsection 3.2.2.4.1, Tributary and Willamette Mainstem Habitat
[14] In USFWS, 2008, Section 5.5, Water Quality

**Decision-making**

The intent in preparing the PEIS is to assist the USACE decisionmaker in making an informed decision, at the program level, through detailed analyses of various alternative O&M options. These analyses will be used to balance interests among various natural resource and human environment impacts and regulatory requirements. The alternatives incorporate combinations of O&M activities to address this balance.

**Future Activities and Subsequent NEPA Analyses**

Construction activities associated with implementation of proposed new structural measures or structural measures to make proposed operations viable may require site-specific analyses tiered from this programmatic NEPA review to disclose localized impacts such as ground disturbance, layout, etc. Limited analyses of the potential site-specific implementation of the general construction activities are included in this PEIS in the resource effects analysis in Chapter 3 to provide a range of potential effects. However, site-specific alternatives development and evaluation would determine the actual features and activities included during the subsequent tiered analyses once the site-specific design objectives and constraints are assessed.

**Chapter Organization**

This chapter discusses the formulation and evaluation of alternatives to meet the purpose and need and is arranged as follows.

- **2.1 Alternatives Development Process** - Summarizes the alternatives development process, including scoping, and the decision-making pr2ocess.
- **2.2 Final Measures Developed for Action Alternatives -** Describes two sets of measures that are carried forward in various action alternatives and the general construction activities associated with measures requiring construction.
    - Measures for flow management, water quality management, and fish passage
    - The Near-term Operations Measures based on the 2021 Court-ordered injunction operations (Section 1.9).
- **2.3 Alternatives Considered but Eliminated from Detailed Study** - Describes the alternatives that were not carried forward for detailed analysis and the reasons for their elimination.
- **2.4 Alternatives Considered in Detail** - Describes the NAA, seven action alternatives that would meet the USACE proposed action and purpose and need statement described in Section 1.3, and measures that are common to all action alternatives.

**Table 1.9-1. Summary of Terminology in the PEIS**

| Term | Definition |
|---|---|
| Willamette Valley System (WVS) | The 13 USACE-managed dams, reservoirs, and revetment in the analysis area. |
| Project(s) | The overall project is the WVS. Individual projects are also identified within the WVS. |
| Components | Current or ongoing structural elements of projects, facilities, and programs within the WVS. |
| Actions | Proposed or ongoing measures incorporated under each alternative to meet the purpose and need for the proposed action. Is synonymous with "measures." |
| Measures | Proposed components or actions that would be taken under each alternative to meet the purpose and need for the proposed action. Is synonymous with "actions." |
| Analysis Area | The area of primary study for resources described as the affected environment in Chapter 3.0. The analysis area in this PEIS is the Willamette River Basin (WRB). |

## 2.1 ALTERNATIVES DEVELOPMENT PROCESS

### The Scoping Process

NEPA requires that lead agencies engage in "an early and open process to determine the scope of issues to be addressed and for identifying the significant issues related to a proposed action" (40 CFR 1501.7). Under the scoping process, lead agencies must conduct several tasks such as inviting participation by other affected federal, state, and local agencies and tribes; determining the scope of significant issues; identifying and eliminating issues that would not be significant to the scope; etc. The results of several of these tasks helps to inform the alternatives development process. Each of the required scoping tasks were conducted by USACE for this PEIS.

In relation to scoping, key purposes and policies of NEPA are to ensure that environmental information is available to citizens before decisions are made (40 CFR 1500.1(b)) and to "encourage and facilitate public involvement in decisions which affect the quality of the human environment" (40 CFR 1500.2(d)). Decisions can include determinations on the range of reasonable alternatives and the scope of those alternatives (i.e., the alternative descriptions and content). As such, agencies involve the public in the scoping process to fulfill these NEPA requirements.

Public involvement for the USACE proposed action began with publication of a 2019 Notice of Intent to prepare an EIS in the Federal Register and inviting participation by the public and other entities. Through the scoping process, USACE solicited input from stakeholders such as tribes, the public (both private citizens and non-governmental organizations [NGOs]), and other agencies. A Scoping Report was prepared at the conclusion of the public scoping process that summarizes the process and comments received (Appendix P).

**Interdisciplinary Preparation and Cooperating Agency Involvement**

To comply with the requirement to engage and consult with other agencies, USACE formed an interdisciplinary team (made up of various technical experts from USACE) that collaborated with basin stakeholders and tribes. Potential federal and state cooperating agencies were also identified and invited to participate in the PEIS development process. Combined, interdisciplinary team, cooperating agencies, tribes, and public input helped to inform the scope of the PEIS including the alternatives development process.

**Overview of the Alternatives Development Process**

Alternatives were developed in accordance with CEQ's NEPA implementing regulations (40 CFR §1502.14). The USACE process involved three key steps: (1) identify primary constraints that would apply to any measure under any alternative, (2) identify primary management and environmental objectives that would also meet the purpose and need for the proposed action, and (3) combining results from the first two steps into formation of a range of alternatives deemed reasonable because they met conditions in Steps 1 and 2.

The following is a summary of this process. Appendix A provides detail on the alternative development process.

**Step 1: Identify Constraints**

Constraints based on the purpose of and need for the proposed action and life safety were identified. Potential alternative measures were eliminated from consideration for the following reasons:

Flood Risk Management (FRM)

Results of the preliminary modeling were used to screen any measures with potential adverse flood risk effects. Specifically, measures that would result in FRM changes from current protection levels were eliminated as an alternative measure.

Dam Safety

USACE performed a preliminary evaluation of measures for dam safety considerations. Measures that would compromise dam safety and that could not be mitigated were eliminated as an alternative measure. A more detailed dam safety evaluation of components will be conducted during site-specific planning and design.

**Step 2: Identify Objectives**

Objectives that would meet the purpose and need for the proposed action in addition to safety risk were identified. The objectives below were identified from the public scoping comments and by the USACE interdisciplinary team, cooperating agency, and tribal input.

1. Allow greater flexibility in water management (related to refill, drawdown timing, and other water management measures) as compared to current operational requirements in water control diagrams and manuals.

2. Increase opportunities for the creation of nature-based structures during maintenance of USACE-managed revetments (structures that help prevent bank erosion) as compared to opportunities under current operations. Nature-based structures are landscape features that are used to provide engineering functions relevant to FRM, while providing economic, environmental, or social benefits.

3. Allow greater flexibility in hydropower production as compared to current operational requirements in water control manuals.

4. Increase anadromous15 ESA-listed fish passage survival at WVS dams as compared to conditions under current operations.

5. Improve water management during the conservation season (related to refill, drawdown timing, and other water management measures), as compared to current operational requirements in water control diagrams and manuals, to benefit anadromous ESA-listed fish and other authorized project purposes.

6. Reduce pollutant levels to restore impaired water quality associated with the WVS dams to benefit anadromous ESA-listed species.

7. Reduce spawning and rearing habitat competition caused by hatchery fish.

**Step 3: Develop a Preliminary Range of Reasonable Alternatives**

A list of measures, or actions, that would meet at least one of the objectives was developed. These measures were formulated based on input from the public scoping comments and cooperating agencies.

Potential measures were then screened. Each measure had to meet the purpose and need for the proposed action, life safety constraints, and achieve at least one of the seven objectives. Each measure also had to be technically feasible, and not result in unacceptable adverse

[15] USACE assumed that formulating improvements for UWR spring Chinook salmon and UWR winter steelhead would also meet needs for other fish species and life stages, such as bull trout.

environmental effects. Appendix A provides detail on measures eliminated from incorporation into an alternative.

Those measures retained after applying screening were then incorporated into alternative options. Measures were incorporated in combinations or around unifying management strategies. An alternative is, therefore, a combination of one or more measures that, together, would address one or more of the USACE objectives described above.

**Step 4: Refine Preliminary Alternatives**

The alternatives described in this PEIS were developed through an iterative process. As information was revealed during the development process, the level of understanding and detail increased, which allowed a hard look at any given potential alternative. This iterative development process fostered informed decisions about the range of alternatives such as how to refine a given alternative or what should be eliminated from alternative descriptions (e.g., a measure or an element of a measure).

Following initial modeling and evaluation of preliminary alternatives, new refined alternatives were developed to assess slightly different combinations of measures and provide clarity on the tradeoffs associated with key measures. The alternatives development process focused on creating strategies to meet at least one objective under individual alternatives (Table 2.1-1). Each alternative strategy placed a different emphasis on the project objectives described in Step 2.

**Table 2.1-1. Project Alternative Strategies and Associated Objectives**

| Alternative | Strategy | Obj. 1[1] | Obj. 2[1] | Obj. 3[1] | Obj. 4[1] | Obj. 5[1] | Obj. 6[1] | Obj. 7[1] |
|---|---|---|---|---|---|---|---|---|
| NAA | Current O&M Practices | X | – | – | – | X | – | – |
| 1 | Improve Fish Passage Through Storage-Focused Measures: Increase the probability of refilling WVS reservoirs and supplemental water delivery for authorized purposes | X | X | X | X | X | X | X |
| 2A, 2B, & 5 | Integrated Water Management Flexibility and ESA-Listed Fish Alternative | X | X | – | X | X | X | X |
| 3A & 3B | Operations Focused: Improve passage of ESA-listed fish through existing structures by modifying water control operations | – | X | – | X | X | X | X |
| 4 | Structures Focused: Improve passage of ESA-listed fish by constructing fish passage and temperature control structures | X | X | X | X | X | X | X |

[1]Note: Objectives include:

1. Allow greater flexibility in water management.
2. Increase opportunities for of nature-based engineering during maintenance of revetments.
3. Allow greater flexibility in hydropower production.
4. Increase anadromous ESA-listed fish passage survival at WVS dams.

5. Improve conservation season water management to benefit anadromous ESA-listed fish and other authorized project purposes.
6. Reduce pollutant levels to restore impaired water quality associated with the WVS dams to benefit anadromous ESA-listed species.
7. Reduce spawning and rearing habitat competition caused by hatchery fish.

**Step 5. Finalize the Range of Alternatives for Incorporation into the Draft PEIS**

The alternatives development process was finalized following the refinement process described in Step 4. The final development process included identification of measures to be incorporated into alternative descriptions as describe below.

The final alternatives analyzed in this PEIS are presented in Section 2.4.4 through Section 2.4.9. Environmental consequences described in Chapter 3 were analyzed under each of these alternatives. These consequences were then compared among the alternatives in Chapter 5.

**Step 6. Evaluate and Compare the Alternatives for Selection of the Preferred Alternative**

The final step was to evaluate and compare each alternative to be analyzed in the PEIS to inform the selection of the Preferred Alternative. USACE utilized a multicriteria decision-making process to assess how well each alternative met the objectives. The criteria were also used to assess tradeoffs between alternatives. Chapter 5 provides additional detail on development of the Preferred Alternative.

## 2.2 FINAL MEASURES DEVELOPED FOR ACTION ALTERNATIVES

This section describes the measures, after screening, that have been incorporated under the alternatives described in Section 2.4.4 through Section 2.4.9 where applicable. Measures are characterized into general categories, including flow, water quality, downstream fish passage, upstream fish passage, and measure common to all action alternatives.

Measures addressing flow were developed to meet Objective 1 and 3 or Objectives 4, 5, and 6 (described in Section 2.1). Water quality measure were developed to address temperature and total dissolved gas [TDG] parameters to meet Objectives 4, 5, and 6. Passage measures were developed to meet Objective 4.

Some measures are location specific, in that the measure was developed to address a problem associated with a specific USACE facility; these locations are identified in the following measure descriptions. Other measures more broadly applied to a subbasin, all facilities, or the system. These were associated with either aquatic habitat downstream of dams or with general O&M required to run the WVS facilities. One measure associated with both downstream habitat and O&M was specifically developed to address Objective 2. Finally, a single measure was developed to address Objective 7.

Each measure was assigned a unique identification number at the start of the measure development process. This identification number was carried through the measure screening process and is provided in parentheses in the measure titles. For example: Provide Pacific Lamprey Passage and Infrastructure (#52) – this is Measure Number 52. This section provides summary measure descriptions.

### 2.2.1 Flow Measures

The amount of water flowing in a river is important to support all life stages of fish species and affects the water quality of the water body. Physical habitat and water quality associated with streamflow are central for meeting the habitat needs of aquatic biota in riverine ecosystems. Thermal conditions can annually exceed biological thresholds in the WRB regardless of streamflow conditions.

This section describes operational measures that would manage streamflow on tributaries and on the mainstem Willamette River through releases from USACE dams.

#### *2.2.1.1 Integrated Temperature and Habitat Flow Regime (#30a)*

Under this measure, dynamic dam outflows would be implemented to increase fish survival and passage. Dynamic dam outflows are also known as adaptive streamflow, or adaptive fish flows. These terms refer to dam flow management techniques that vary based on the amount and temperature of water required by fish below the dam. This flow regime is described in Appendix A, and the associated modeling parameters and results are provided in Appendix B.

The proposed integrated temperature and habitat flow regime is based on three components:

- Alternative flow targets that incorporate magnitude, seasonal variation, and annual hydrologic conditions;
- Opportunistic/adaptable water releases for real-time water temperature management; and
- Fall maximum outflows from Detroit/Big Cliff, Green Peter/Foster, Cougar, and Lookout Point/Dexter Dams.

In developing the integrated temperature and habitat flow regime, USACE assumed that prioritizing adult UWR spring Chinook salmon would also meet critical habitat needs for other fish species and life stages, such as bull trout. Under this priority, USACE could also address pre-spawn mortality, which is the rate at which targeted fish species die before they are able to spawn (reproduce) and thus contribute to the population.

Pre-spawn mortality substantially constrains productivity of UWR spring Chinook salmon, so by directly addressing pre-spawn mortality, these adaptive fish flows are addressing a critical factor to avoid jeopardizing this listed species. USACE developed these adaptive fish flows by considering the timing of their freshwater migration, holding, and spawning, all three of which extend from early spring to the fall months.

Flow targets for wet and dry years for the major tributaries regulated by WVS dams on the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette Rivers were developed based on hydrologic conditions in any given year. These flow targets depend on how much the reservoir fills in the conservation season. The flow targets from the NMFS 2008 BiOp were carried forward for other dams and sub-basins.

Fish flows under this regime also incorporate temperature pulse flows during the period from May through June. Temperature pulse flows reduce and stabilize water temperature during important timeframes for UWR spring Chinook salmon and UWR winter steelhead, mitigating warmer air temperatures to the extent possible. These adaptive flows are in addition to the base flow releases.

The specific flow targets for adaptive flow releases were based on the observed relationship between flow, air temperature, and water temperature during 2001-2018. If air temperature were forecasted to be above the threshold, additional flow from the WVS dams would occur according to the limits defined for each period. Source of flow augmentation would be determined based on current conditions of the reservoirs and adaptively managed to meet the specific need. These proposed fish flow targets are intended to reduce thermal stress on ESA-listed fish and reduce mortality during extreme heat.

Redds are instream nests created by female salmonids to lay eggs and are also crucial to early-stage juveniles, or fry. Some redd areas can become dewatered after reservoirs are drafted for FRM, reducing egg and fry survival. Ensuring higher flows in these areas can encourage spawning and reduce egg and fry mortality. Therefore, as a part of this measure, from September 1 to October 15, maximum outflows from Detroit/Big Cliff, Green Peter/Foster, Cougar, and Lookout Point/Dexter Dams would be applied to protect against redd dewatering. The spawning flow level was chosen to help balance the need to encourage spawning in areas that would remain wetted after reservoir drafting and the need to increase flows to draft reservoirs for flood management.

#### *2.2.1.2 Refined Integrated Temperature and Habitat Flow Regime (#30b)*

This measure is a modification of Measure #30a with changes to the mainstem and tributary flow targets. Flows are subject to change throughout the season based on realized hydrology and annual water management decisions. Additional water may be released from the projects to achieve temperature targets in the mainstem as measured at Salem, as noted in Measure #30a.

Under this measure, mainstem flow targets at Salem and minimum flow thresholds at Detroit/Big Cliff, Lookout Point/Dexter, and Foster Dams would be modified according to the flow targets provided in Appendix A. The associated modeling parameters and results for each alternative that includes this measure are provided in Appendix B.

#### *2.2.1.3 Augment Instream Flows by Using the Power Pool (#304)*

Under this measure, water stored within power pools would be used to supplement downstream flows to assist in meeting minimum tributary flows during the summer and late fall. Using water from the power pool would occur when natural stream flows are not adequate to provide the biologically justified flows. The measure would only be implemented to meet ESA obligations and not to provide water to meet consumptive needs of downstream M&I and irrigation users.

Due to the annual variability in hydrologic conditions throughout the basin, a set priority for use of the power pools is not possible and would be determined on an as-needed basis according to flow conditions in the tributaries (Table 1.5-3). An annual coordination process would be defined. The draft limits would be based on project location (Table 2.3-1).

**Table 2.2-1. Minimum Power Pool Elevations and Storage Volume**

| Project | Lowest Proposed Draft Limit (Minimum Power Pool Elevation) (feet) | Minimum Conservation Pool Elevation (feet) | Power Pool Storage Volume (acre-feet) | Power Pool Storage (percent of total storage) |
|---|---|---|---|---|
| Detroit | 1,425 | 1,450 | 36,375 | 21.2 |
| Green Peter | 887 | 922 | 62,600 | 36.5 |
| Lookout Point | 819 | 825 | 11,377 | 6.6 |
| Hills Creek | 1,414 | 1,448 | 48,800 | 28.5 |
| Cougar | 1,516 | 1,532 | 8,700 | 5.1 |

The re-regulating reservoirs at Dexter and Big Cliff Projects do not have power pool storage. Foster Dam has the smallest amount of power pool storage in the WVS (3.6 acre-feet); the available amount is negligible in comparison to the other reservoirs with power pool storage in the WVS. Therefore, Dexter, Big Cliff, and Foster Projects are not included with this measure.

#### *2.2.1.4 Augment Instream Flows by Using the Inactive Pool (#718)*

Under this measure, instream flows would be augmented using the inactive pool. The inactive pool is designed to trap sediment and is the lowest storage area in a reservoir.

The inactive storage by volume for these four reservoirs is listed in Table 2.3-2. Because the inactive pool is the last available storage in a reservoir, inactive pool water is traditionally reserved for extreme droughts, emergencies, and used only after the conservation pool has been emptied. Drafting into inactive storage increases the risk of not refilling the reservoirs depending on the water year.

**Table 2.2-2. Inactive Storage Volume by Project**

| Project | Inactive Storage Volume (acre-feet) | Inactive Storage (percent of total storage) |
|---|---|---|
| Blue River | 3,430 | 1.0 |
| Cottage Grove | 3,139 | 0.9 |
| Dorena | 7,355 | 2.0 |
| Fall Creek | 9,505 | 2.6 |

Using the inactive pools would assist in meeting minimum flows at the downstream control points (shown in Figure 2.3-1) during the late summer and fall (shown in Figure 2.3-1). The reservoirs are generally not drafted below their minimum conservation pools unless hydrologic conditions result in reservoir inflows less than what is needed to provide downstream minimum flows.

Water stored in the designated inactive pools would be used to support biological flow targets when natural stream flows are inadequate to provide the biologically justified flows. This measure would allow the water stored in the inactive pool to be used when needed without additional analysis on a case-by-case or year-by-year basis.

The lowest outlet in the reservoir would be used to draft the reservoir to the desired elevation without a need for structural modifications. If the minimum conservation pool elevation is reached before September 1, the elevation would be dropped to the low flow target. If the minimum conservation pool elevation is reached after September 1, the existing flow target would be retained.


**Figure 2.2-1. Study Area Sub-basins and Control Points (illustrates USACE-managed dams only)**

#### *2.2.1.5 Reduce Minimum Flows to Congressionally Authorized Minimum Flow Requirements (#723)*

Under this measure, minimum flows would be reduced to the Congressionally authorized minimum flows to benefit reservoir refill objectives. This would allow reservoirs to capture more spring runoff rather than releasing it.

The spring and summer tributary flow targets would be based on operating equipment limitations at the projects and would occur year-round. The summer mainstem flow targets are based on the flow targets identified in HD531 for Albany and Salem and would occur from June through September (Table 2.2-3 and Table 2.2-4).

**Table 2.2-3. Tributary Flows from HD531 at Project Locations**

| Dam | Minimum Flow (cfs)1 | Remarks on Limits |
|---|---|---|
| Detroit/Big Cliff | 1000/750 | 1 Feb – 30 Jun = 1000 cfs<br>1 Jul – 30 Nov = 750 cfs |
| Blue River | 30 | 1 Feb – 30 Jun = 30 cfs<br>1 Jul – 30 Nov = 30 cfs |
| Cottage Grove | 75/50 | 1 Feb – 30 Jun = 75 cfs<br>1 Jul – 30 Nov = 50 cfs |
| Cougar | 300/200 | 1 Feb – 30 Jun = 300 cfs<br>1 Jul – 30 Nov = 200 cfs |
| Dorena | 190/100 | 1 Feb – 30 Jun = 190 cfs<br>1 Jul – 30 Nov = 100 cfs |
| Fall Creek | 30 | 1 Feb – 30 Jun = 30 cfs<br>1 Jul – 30 Nov = 30 cfs |
| Fern Ridge | 50/30 | 1 Dec – 30 Jun = 50 cfs<br>1 Jul – 30 Nov = 30 cfs |
| Green Peter/Foster | 50 | 1 Feb – 30 Nov = 50 cfs<br><br>HD531 was adopted prior to Foster Dam being proposed; hence the minimum flow released at Green Peter Dam is the 50 cfs but also that needed to ensure Foster minimum flows. |
| Foster | 800 – 400 | 1 Feb – 30 Apr = 800 cfs<br>1 May – 31 May = 750<br>1 Jun – 30 Jun = 600<br>1 Jul – 30 Nov = 400 cfs |

| Dam | Minimum Flow (cfs)1 | Remarks on Limits |
|---|---|---|
| | | Foster was not included in HD 531; therefore, minimum flow from Foster Dam is the combined minimum for Green Peter and Cascadia Dams. |
| Hills Creek | 100 | 1 Feb – 30 Jun = 100 cfs<br>1 Jul – 30 Nov = 100 cfs |
| Lookout Point/Dexter | 1200/1000 | 1 Feb – 30 Jun = 1200 cfs<br>1 Jul – 30 Nov = 1000 cfs |

cfs=cubic feet per second

**Table 2.2-4. Mainstem Flows**

| Control Point | Date | Augmentation for Fish Habitat and Water Quality (cfs)*1 |
|---|---|---|
| Salem | Jun 1 – Nov 30 | 6,500 |
| Albany | Jun 1 – Nov 30 | 5,000 |

*Note: Numbers provided are per HD531

[1]cfs = cubic feet per second

### 2.2.2 Water Quality Measures

Water quality downstream of a dam can affect all life stages of fish species. Temperature is an important environmental factor affecting salmonid distribution, behavior, and physiology (Groot and Margolis, 1991; Brett 1995; Newell and Quinn, 2005) and affects their distributions and migratory behavior (Behnke, 1992; Quinn, 2005).

Downstream water temperatures in the WVB affected by the dams disrupt fish spawning and rearing life stages because water is too warm in the fall/winter and too cool in the summer/spring. Most of the WVS dams are considered high head dams, meaning they are over 100 feet tall. As a result, their deep reservoirs experience thermal stratification in summer.

Thermal stratification occurs when the warming of the reservoir’s surface by the sun causes water density variations and cooler, denser water settles to the bottom of the reservoir. A layer of warmer water floats on top.

The coldest water will be released in the summer if the only available outlets for releasing water are the deep regulating outlets (ROs) or if a deep penstock is being used to create power (Figure 1.8-2).

WRB rivers have been historically warmer in the summer than under current conditions. Fish adapted to the historical, warm summer conditions; therefore, the unseasonably cool water released from the reservoirs disrupts their life stages in summer. By fall, most of this cool water has been released, leaving mostly warm surface water at a time when rivers would historically be cooling off with increased precipitation, further disrupting salmonid life stages. In the winter a lake may "turnover" meaning cooler water will move to the surface and any remaining warmer water will move to the bottom.

Total dissolved gas (TDG) supersaturation also negatively effects environmental effects fish and other aquatic species (EPA, 1973). Discharging water through the spillway or ROs entraps air in the plunge pools downstream from the dams, leading to increasing TDG in the downstream river (Qu L. et al., 2011). TDG supersaturation can easily cause fish to suffer from gas bubble disease (GBD) by producing air bubble blockages in the blood, heart, and gill filaments (Johnson E. et al., 2005). GBD can cause a variety of physiological impairments to fish and negatively impact their typical life processes, increasing the mortality of both adult and juvenile fish (Weitkamp et al., 1980).

Based on Clean Water Act (CWA) requirements, state and resource agencies have implemented temperature total maximum daily loads (TMDLs) for both temperature and TDG. A TMDL is a plan for restoring impaired waters that identifies the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards.

The TMDLs in the WRB provide temperature targets throughout the year to coincide with life cycle stages of ESA listed fish. This section describes the structural and operational measures to address temperature and TDG. Details specific to each basin/reservoir are provided where appropriate.

#### *2.2.2.1 Construct Water Temperature Control Towers (#105)*

Under this measure, Selective Withdrawal Structures (SWS), often referred to as Water Temperature Control (WTC) towers, would be constructed to help regulate water temperatures downstream of projects. Figure 1.5-10**Error! Reference source not found.** shows a WTC completed at Cougar Dam in 2005. This shows one possible design that could be constructed at other dams in the WVS.

SWSs blend warmer surface water with cooler deep water by using multiple gates at varying elevations within the reservoir to meet CWA and ESA requirements downstream of the proposed project locations (

Figure 2.3-2). The SWSs would allow USACE to send this blended water through the powerhouses and continue to generate power while still meeting downstream water quality targets. Site-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared for the construction of each SWS tower.

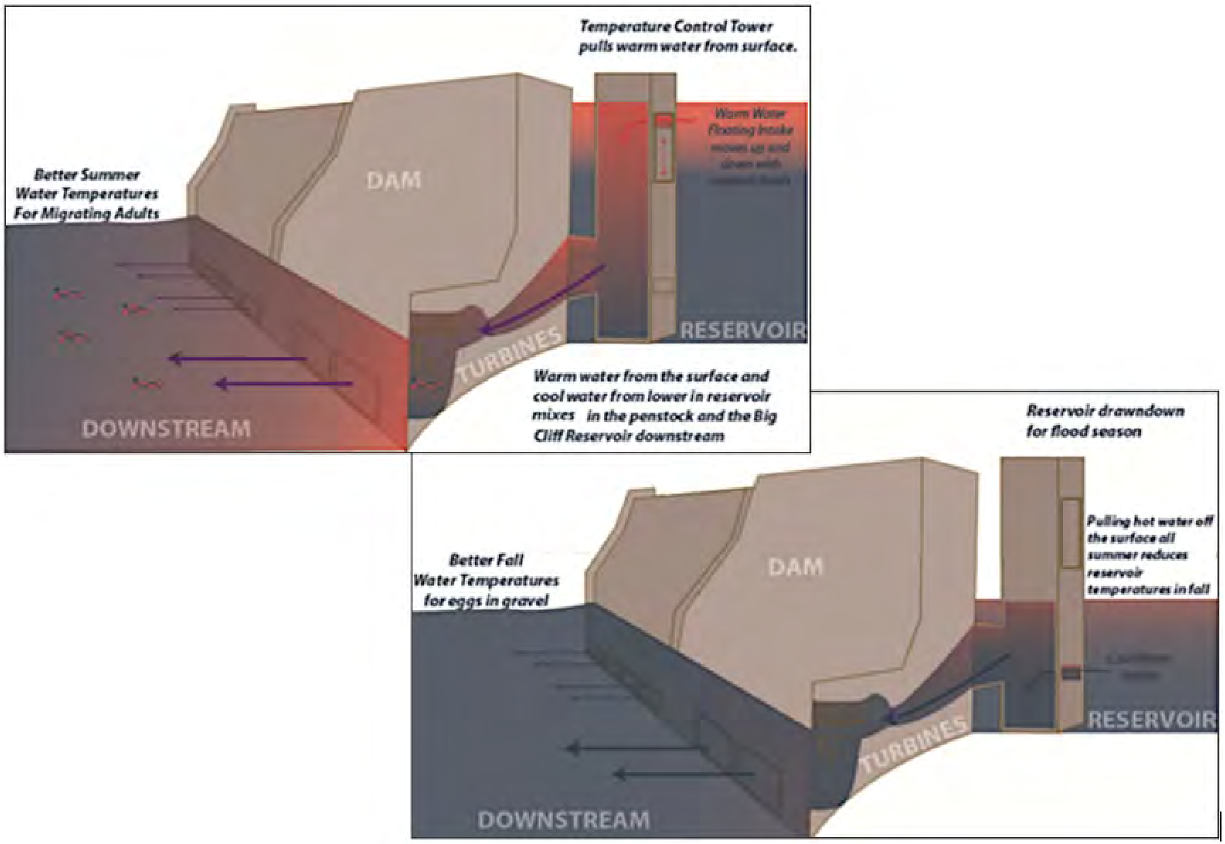


**Figure 2.2-2. Graphic Representation of SWS Operation (at Detroit Dam)**

### *2.2.2.2 Use Regulating Outlets for Temperature Management (#166)*

Under this measure, projects that have regulating outlets (RO) would release relatively cool water from the ROs during the fall to benefit natural UWR spring Chinook salmon egg incubation. Table 2.3-5 provides the dams where this measure is proposed, the outlet elevation for each and any restrictions.

**Table 2.2-5. Outlet Elevations and Current Restrictions**

| RO Location | Outlet Elevation (feet) | Current Restrictions |
|---|---|---|
| Green Peter | 745 | No restrictions |
| Lookout Point | 724 | No restrictions |
| Detroit Upper | 1,335 | Usable when lake is below 1,541 feet |
| Detroit Lower | 1,260 | Usable when lake is below 1,460 feet |

The WVS reservoirs experience strong temperature stratification during the spring, summer, and fall before reservoir turnover. Generally, warm water rises and cool water sinks, resulting in the stratification of reservoirs with the warmest water on the surface and the coldest at the bottom. When the reservoir is stratified, there is an opportunity at some dams to release relatively cool water from the ROs below the power intakes. This water is comparatively cooler than that released through the turbines and can provide a benefit for spring Chinook salmon egg incubation downstream.

Regulating outlets consist of tunnels and gates through the dams. They are designed to provide a means of releasing reservoir water apart from turbine outlets and spillways. Regulating outlets are used to manage a range of flows from low flow all the way up to activation of the spillway and can be used in combination with the spillway to manage very high flows. Figure 2.3-3 illustrates a configuration of ROs, spillway, and penstock outlet at Detroit dam.

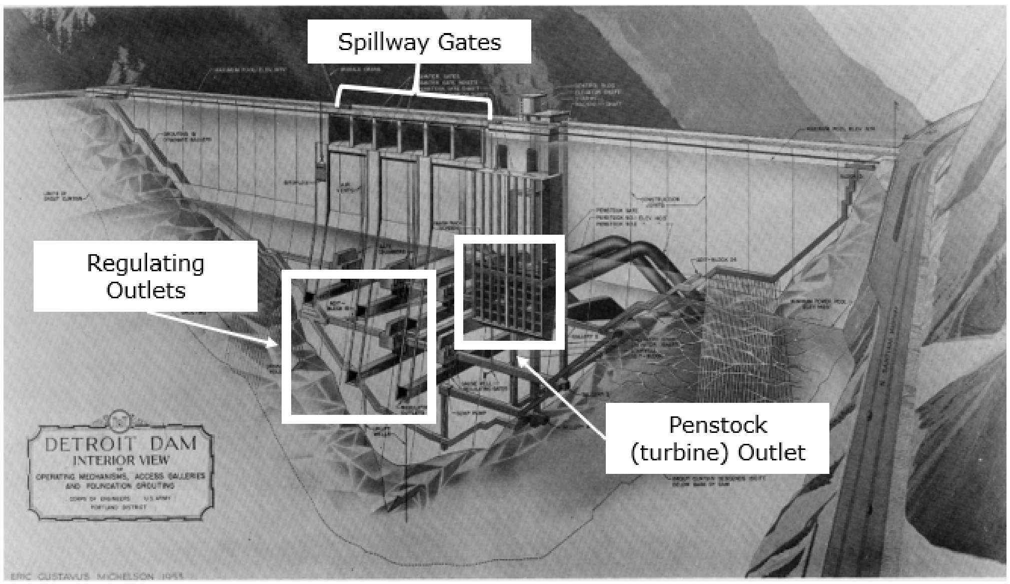


**Figure 2.2-3. Interior View of Detroit Dam Showing the Outlet Configuration**

Depending on the dam, the RO and spillway can be used simultaneously. There is limited benefit of this measure at Lookout Point and Green Peter Dams due to the close proximity of the ROs to the turbines. Likewise, the ability of the lower ROs to expel cold water during fall provides limited benefit as the operation has a relatively short duration (a few weeks) before flood season begins and the reservoirs begin to refill.

While the ROs were designed for use during high flows, they were not specifically designed for regular usage at relatively low flow or frequent gate changes, as is often desired for temperature management. The ROs are also aging and would need to be reinforced and modernized if they are to be used routinely with high head pressure (during times when the lake is full).

For example, under this measure at Detroit Dam, the lining of the RO tunnels may need to be reinforced and gate reliability would likely need to be improved to limit the effects of cavitation, a corrosive process that can lead to major damage to dam structures (Figure 2.3-4) and scouring of the dam when head pressure exceeds 200 feet above an outlet. Use of additional outlets would provide additional capability to release cooler flows in the late fall (typically November). Work to address cavitation and gate reliability would be performed as a part of normal maintenance activities.

This measure would be implemented in the timeframe between October 1 and November 15. The implementation frequency and duration of this measure would be dependent on the seasonal reservoir hydrology and temperature conditions as well as the observed conditions downstream of the project.

**Figure 2.2-4. Photo of Cavitation Damage to Upper RO Tunnel**

#### *2.2.2.3 Structural Improvements to Reduce Total Dissolved Gas (#174)*

Under this measure, structural improvements would be implemented to reduce TDG. Measures may include:

- Structural modifications focused on the redesign of current outlets, spillways, or stilling basins that should not increase erosional scouring forces that would decrease structural integrity of the dam.
    - Deflectors (Figure 2.3-5) installed at the base of spillways that redirect the spill jet, which transports air bubbles deep into the stilling basin, to a horizontal jet that maintains entrained air closer to the water surface. Allowing the entrained air to dissipate more quickly, thus reducing the probability of fish contracting GBD.
    - Boulder augmentation or debris jams that create more natural riffles downstream of dams and help de-gas supersaturated water.
    - Implementation of spill patterns that distribute spill bay flows uniformly across the entire spillway to help reduce downstream TDG.
    - Constructing pipe extensions on the downstream side of ROs to submerge releases in the stilling basin and reduce jet impact on the tailwater surface.

- Integration of TDG management in the design of new SWSs. While SWSs reduce, to some degree, the amount of spill that typically occurs during operational temperature management and, therefore the amount of TDG, elevated TDG would still likely exist during high flow events, turbine outages, or turbine maintenance. Therefore, the design of new SWSs should incorporate how/if to address TDG abatement.
- Site-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared for the construction of this measure at each location.

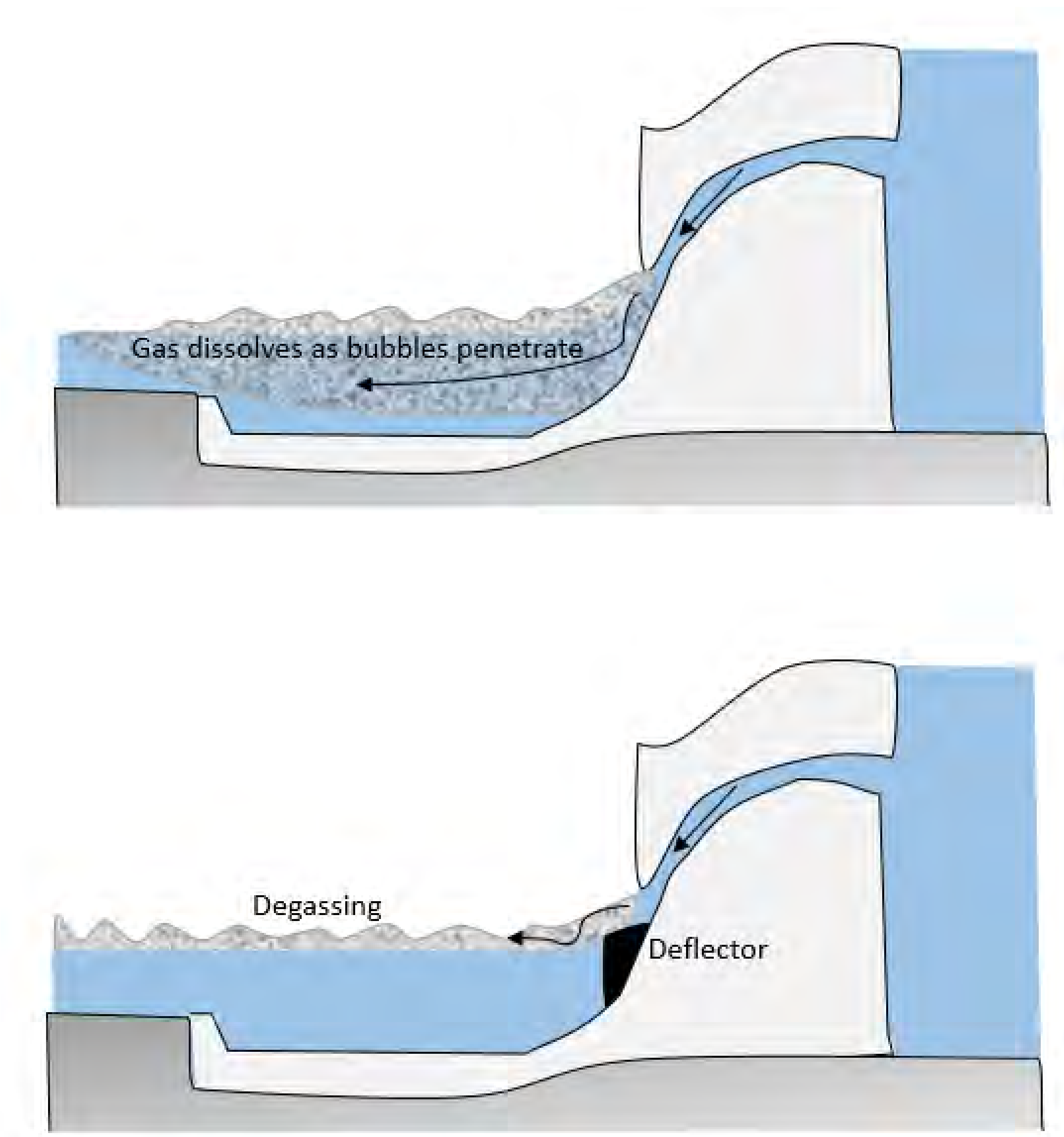


**Figure 2.2-5. Spillway Deflector Reducing Total Dissolved Gas**

### *2.2.2.4 Foster Dam Fish Ladder Temperature Improvement (#479)*

Currently, upstream fish migration at Foster Dam has been observed to be delayed, and consensus among regional fisheries managers is that the temperature of the water in the fish ladder is too cold to attract fish in the spring and early summer (May and June). This measure would provide more normative temperatures at the fish ladder entrance. Under this measure, a structural modification to Foster Dam would be implemented to reduce delay of upstream-migrating UWR spring Chinook salmon and UWR winter steelhead by increasing the water temperature in the fish ladder.

During the later spring and summer months, the Foster forebay is temperature stratified. The existing water supply for the fish ladder is located at the powerhouse intakes at a depth where the water is coldest when the reservoir is stratified. As a result, the temperature of the flow issuing from the pre-sort pool at the top of the fish ladder and from the ladder entrances is too cold compared to the historic or ambient river temperatures.

The major feature of this measure is construction of a new Forebay Warm Water Supply (FWWS) pipe that would draw warm water from near the surface of the reservoir in the Foster forebay. The existing water supply pipe would remain in use, and a network of pipes and valves would allow the two water sources to be mixed to achieve desired temperatures at the adult fish facility.

The temperature targets were developed as a function of the upstream South Santiam River, with maximum target temperatures constrained by needs for fish health. A juvenile fish exclusion screen would be provided upstream of the FWWS intake to keep juvenile fish from entering the pipe.

Figure 2.3-6 provides a piping schematic and identifies the four temperature target locations. Site-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared for the construction of this measure.

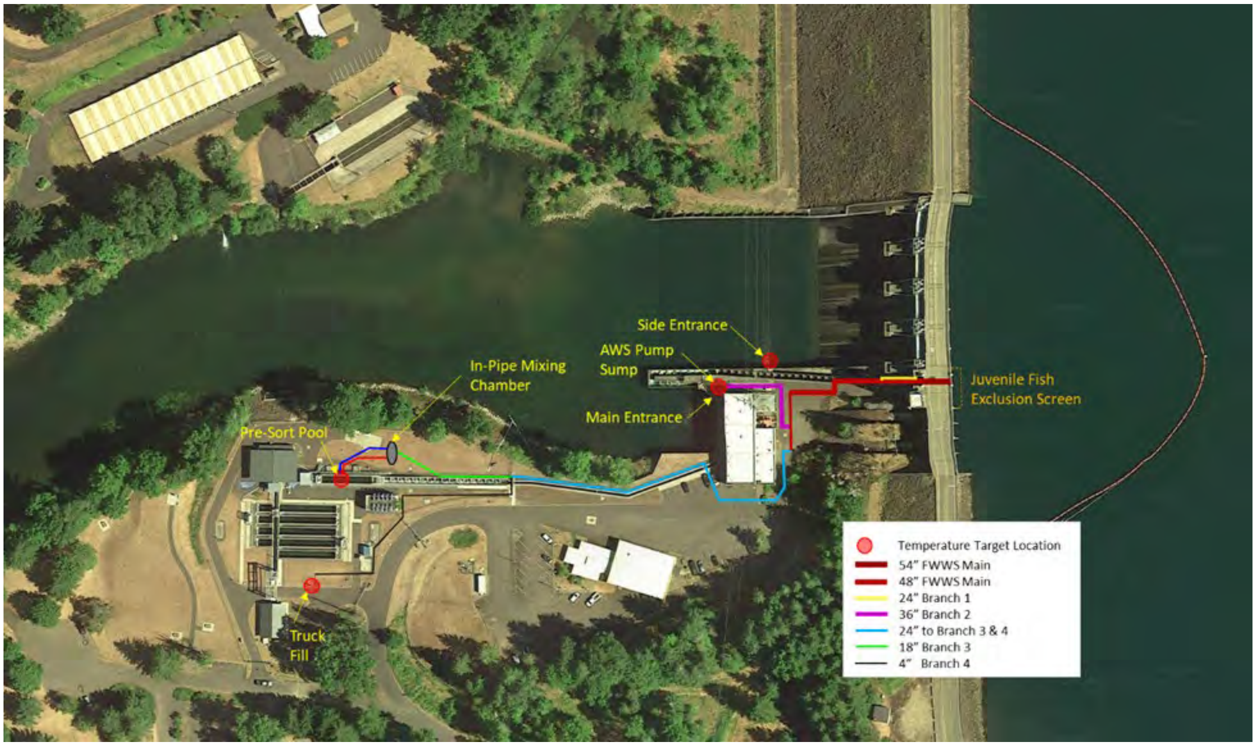


**Figure 2.2-6. FWWS Piping Schematic with Temperature Target Locations (at Foster Dam)**

### *2.2.2.5 Use Spillways to Release Warm Surface Water in Summer (#721)*

Under this measure, spillways would be used to further improve downstream water temperature management into the fall (Table 2.3-6). A larger volume of warm surface water from the reservoirs could be released by extending the use of the spillway, while deeper cold water could be reserved for later in the fall and early winter when necessary for fish incubation (Figure 2.3-7). The actual mix between outlets would depend on temperature targets. At Detroit, Lookout Point, Hills Creek, and Green Peter Dams, the minimum flow of 60 percent of total outflow during a specified period would be targeted.

Structural modifications would be required to use the spillways at Hills Creek and Blue River for this measure because they were designed for only occasional use in FRM operations. The Hills Creek Dam spillway channel (Figure 2.3-8) and spillway gates would require modifications to allow for low flow rates and a useable low-flow channel that would not affect the powerhouse.

The fish weir at Foster Dam would also need to be modified to implement this measure.

Site-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared for necessary modifications at Hills Creek, Blue River, and Foster Dams.

**Table 2.2-6. Spillway Elevation and Durations for Warm Surface Water Releases**

| Location | Spillway Elevation (feet) | Approximate Duration (dates) |
|---|---|---|
| Lookout Point | 888 | June 1 – August 1 |
| Hills Creek | 1,495 | May – July |
| Blue River | 1,321 | May – July |
| Foster | 597 | May – July |
| Green Peter | 969 | June1 – August 1 |
| Detroit | 1,541 | April 15 – August 30 |

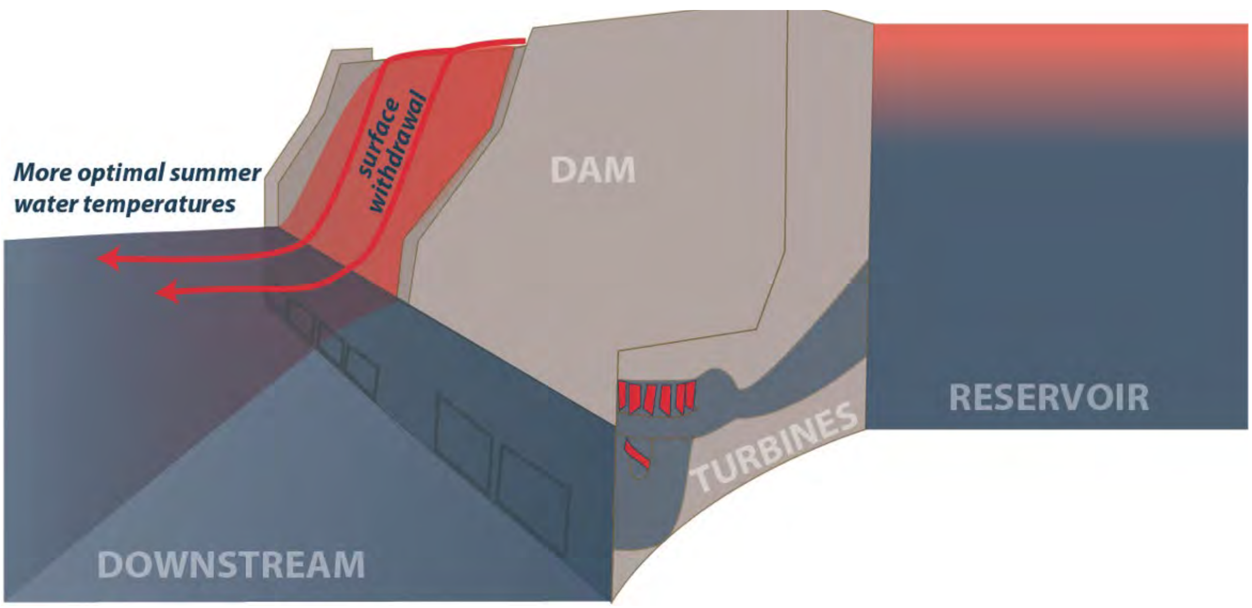


**Figure 2.2-7. Graphic Representation of Warm Water Surface Spill over a Dam's Spillway**

**Figure 2.2-8. Hills Creek Dam Spillway Channel**

### 2.2.3 Downstream Fish Passage Measures

Juvenile UWR spring Chinook salmon and UWR winter steelhead located upstream of WVS dams must pass the dam to migrate downstream on their way to the ocean. The fish will actively search for a way downstream and are strongly directed by the current. Juvenile salmonids are also surface oriented, meaning they migrate close to the water surface and are not likely to dive in search of a passage through deep outlets.

Some dam passage routes are also safer than others. The safest and easiest to find a way through a dam is usually a spillway. However, a large volume of water, and therefore strong current, also passes through the dam's turbines. This can be a dangerous and difficult course for juvenile fish. This section describes the structural and operational measures to improve downstream fish passage. Details specific to each basin/reservoir are provided where appropriate.

#### *2.2.3.1 Deeper Fall Reservoir Drawdown for Downstream Fish Passage (#40)*

Under this measure, reservoir elevation would be decreased in the fall to 25 feet over a dam’s ROs (or at Cougar Dam the Diversion Tunnel [DT]) to improve downstream passage for migrating ESA-listed and other fish. Fish are more likely to survive passage when the water elevation over the outlet is relatively shallow; higher elevations of water over the outlet result in lower survival rates during passage. Water levels below the outlet would not allow for passage at all. The dams and outlets at which this measure would be implemented depend on the alternative. Dams where this measure could be implemented include Detroit, Green Peter, Lookout Point, Hills Creek, Blue River, and Cougar Dams.

At Cougar Dam, this measure could alternatively involve drawing down to the RO or within 25 feet of the Diversion Tunnel (DT), located at the bottom of the reservoir (Figure 2.3-9), depending on the alternative. A drawdown to the DT at Cougar would require several dam modifications to make this operation possible and a change in operational authority.

First, dam safety concerns associated with Cougar Reservoir's fluctuating pool levels would need to be addressed. Second, redundant gate structures to allow for safe, remote, routine operation of the DT would need to be designed and constructed. Finally, the DT would need to be made accessible for O&M through the construction of a tower and bridge. Site-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared for these required modifications.

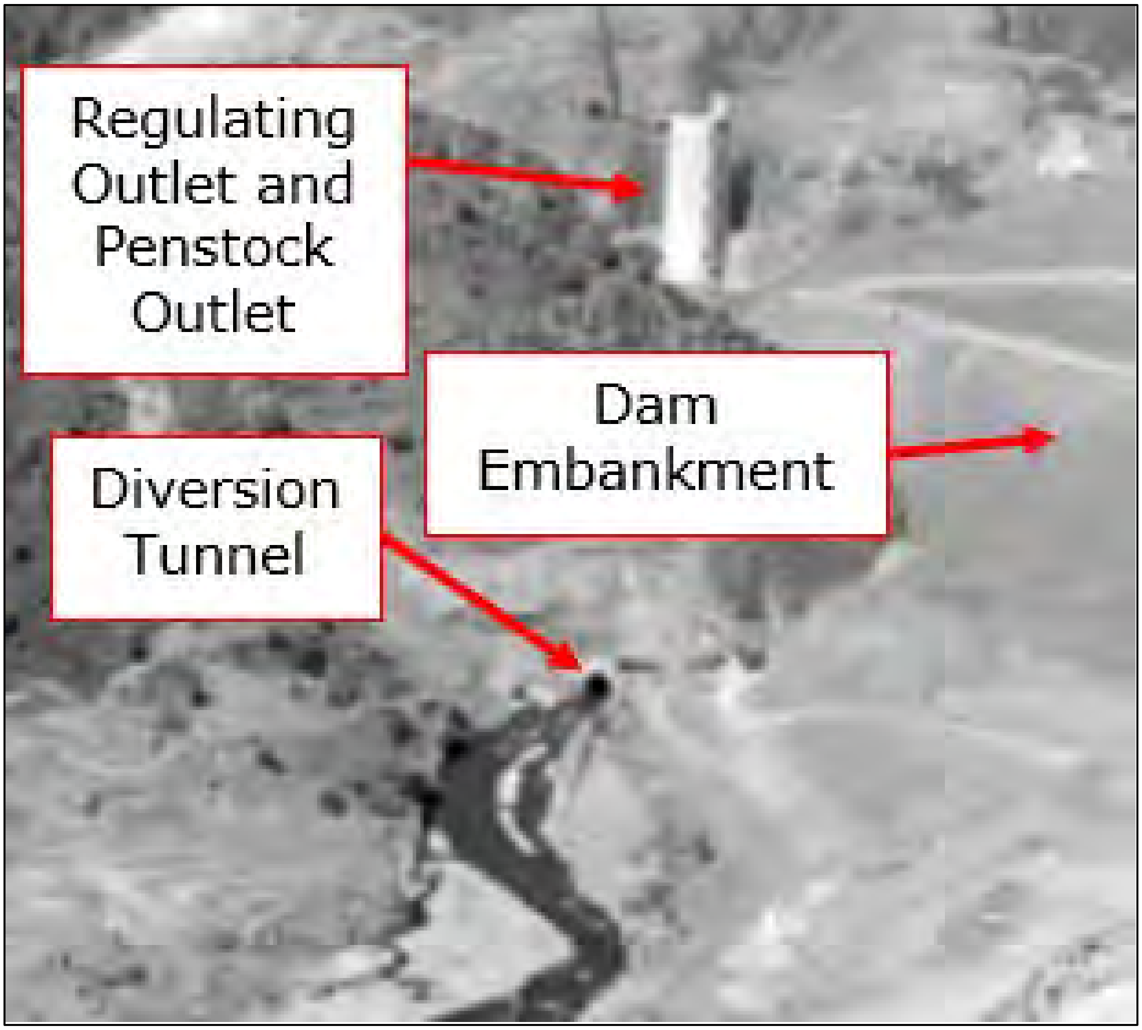


**Figure 2.2-9. 1960s Photograph of Cougar Dam Diversion Tunnel**

Drafting of each reservoir would begin on or about July 1 each year and would proceed at a rate necessary to achieve the October 1 rule curve elevation on September 1 (number 1 in Figure 2.3-10). During the September 1 to October 15 spawning season for UWR spring Chinook salmon, the total discharge from the dam would be maintained at or below the maximum flows for spawning (number 2 in Figure 2.3-10) as shown in Table 2.3-7. After the spawning season ends on October 15, the draft rate would then be revised as needed to achieve the November 15 target elevation (Table 2.3-7) on November 10 (number 3 in Figure 2.3-10).

Pool target elevations (Figure 2.3-10) would be achieved beginning at the earliest on November 15 and at the latest on December 15 (Number 4 in Figure 2.3-10, developed for demonstration only). Turbine operations would be limited from dusk to dawn and whenever reservoir elevation is at or below 50 feet over the top of the penstock; and during the dates of October 15 to December 15.

Reservoirs would be operated at the fish passage target elevations, shown in Table 2.3-7, for 21 days. Three weeks was chosen due to the observed response of juvenile UWR spring Chinook salmon to fall operations when pool elevations are reduced closer to ROs (e.g., Nesbit, 2012; Keefer et al., 2013). Observations indicate most juveniles will pass downstream during the reservoir drawdown period before the target elevation is achieved, and likely within hours to a few days after it is achieved.

Three weeks was also chosen to provide additional opportunity to pass juvenile UWR spring Chinook salmon downstream that may move downstream from the upper reservoir, while balancing time for refill back to minimum conservation pool elevation before February 1st. This would avoid impacting the ability to augment downstream flows during the following conservation season.

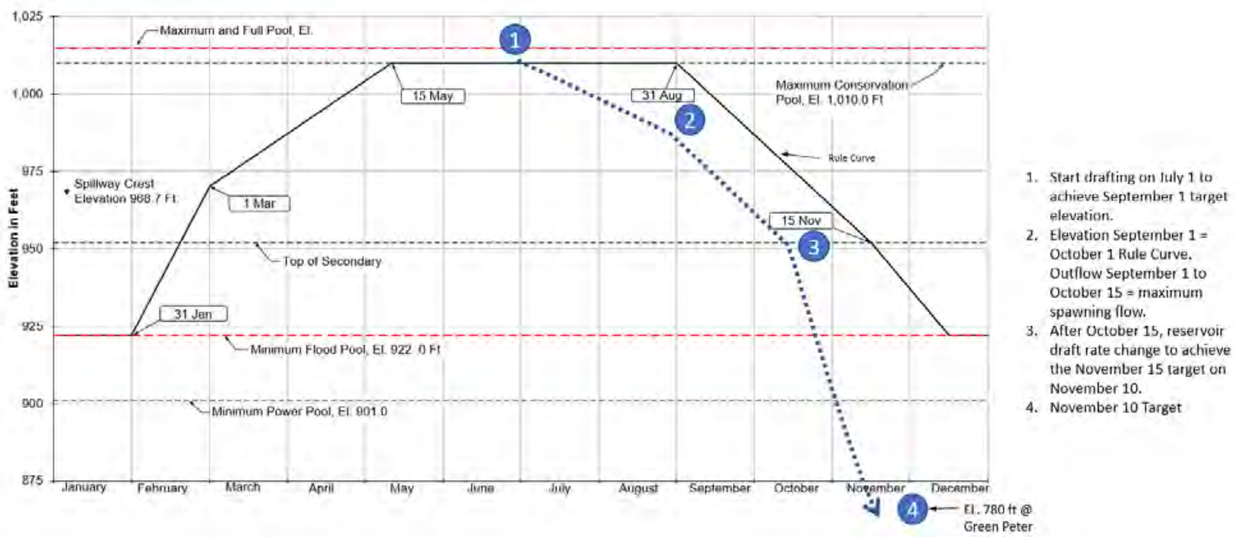


**Figure 2.2-10. Example Green Peter Rule Curve for Reservoir Drafting Approach**

**Table 2.2-7. Fall Reservoir Drawdown Target Elevations[1]**

| Dam | Target Elevation (feet) (25 feet above top of the outlet)[1] |
|---|---|
| Detroit | 1,375 |
| Green Peter | 780 |
| Lookout Point | 761 |
| Hills Creek | 1,446 |
| Blue River | 1,165 |
| Cougar RO | 1,517 |
| Cougar DT | 1,330 |

[1] These are the top of ROs (plus 25 feet) and elevations below which turbine operations would be limited between 10:00 a.m. and 6:00 p.m. daily.

Target elevations = invert elevation + height of outlet + 25 feet

#### *2.2.3.2 Pass Water over Spillways in Spring for Downstream Fish Passage (#714)*

Under this measure, water would be discharged using the spillway in late spring and early summer to increase the survival and passage rate of juvenile UWR spring Chinook salmon and UWR winter steelhead passing downstream. The spillway outflow attracts migrating juvenile salmonids, which can use the spillway flows to pass the dam rather than going through the turbines. The dams at which this measure would be implemented depend on the alternative.

Factors considered in determination of facilities that warrant implementation of this measure include the types of turbines, the hydraulic head of the dam, and the downstream biological impact due to elevated TDG levels from spill operations. Dams where this measure could be implemented include Big Cliff, Detroit, Dexter, Lookout Point, Hills Creek, Fall Creek, Green Peter, and Cougar Dams. The measure would start approximately May 1, or as soon as pool elevation allows, and run until July 1, or as long as hydrology supports the operation. The maximum pool elevation would be less than or equal to 25 feet above spillway crest.

Structural modifications would be required to safely implement this measure at Hills Creek Dam because the spillway was not designed for frequent use; it was designed to occasionally pass fill due to flooding events. Site-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared for necessary modifications at Hills Creek Dam.

#### *2.2.3.3 Deep Spring Reservoir Drawdown for Downstream Fish Passage (#720)*

Under this measure, reservoir elevation would be decreased in the spring to 25 feet over a dam’s ROs or DT to improve downstream passage for migrating ESA-listed and other fish.

At Cougar Dam this measure could alternatively involve drawing down to the RO or within 25 feet of the DT at the bottom of the reservoir, depending on the alternative (Figure 2.3-9). A drawdown to the DT at Cougar Dam would require several dam modifications to make this operation possible, as described in Section 2.3.3.1 for Measure #40. Site-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared for the construction of these required modifications at Cougar Dam.

Details on the operation of this measure are provided for each dam in Table 2.2-8, including the target elevation and the duration the reservoir would be held at this elevation. For operation of this measure, beginning February 1, the reservoir would be drafted down as needed to reach the target elevation by May 1. The target elevation would be held until June 15, as hydrology allows, to increase survival of juvenile UWR spring Chinook salmon and UWR winter steelhead during downstream passage.

**Table 2.2-8. Reservoir Drawdown Target Elevations**

| Dam | Target Elevation (feet) (25 feet above top of the outlet)[1] | Duration Held at this Elevation (weeks) |
|---|---|---|
| Detroit | 1,375 | 6 |
| Green Peter | 780 | 3 |
| Lookout Point | 761 | 6 |
| Hills Creek | 1,446 | 6 |
| Cougar RO | 1,517 | 6 |
| Cougar DT | 1,330 | 6 |

[1]These are targets. If a reservoir is lower, it would be filled to the target (inflow allowing) while meeting minimum flows; if higher, it would be drafted without exceeding maximum flows.

### *2.2.3.4 Construct Structural Downstream Fish Passage (#392)*

Under this measure, downstream fish passage structures would be constructed to provide passage for migrating ESA-listed and other native fish. Downstream fish passage structures for anadromous smolts migrating toward the ocean fundamentally differ from upstream fish passage structures for adults travelling upstream to spawn.

Upstream fish passage in the WVS involves adult fish collection facilities located downstream of a dam. Fish are collected and transported via truck to a location above the reservoir.

Downstream fish passage structures either float in the reservoir or are attached to the dam's spillway. For in-reservoir floating structures, juvenile fish are collected near the dam and transported downstream via 'trap and haul' methods like upstream passage methods (Figure 1.6-4). In the case of downstream passage structures attached to the dam, fish are allowed to volitionally swim over the spillway structure and past the dam.

A description of in-reservoir floating structures and a downstream structure attached to the dam is provided below. Site-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared for construction of either type of downstream fish passage structure.

#### *2.2.3.4.1 Structural Downstream Fish Passage at Detroit, Green Peter, Cougar, Lookout Point, and Hills Creek Dams*

Under this measure a floating downstream passage structure would be constructed and operated to capture downstream migrating UWR spring Chinook salmon and UWR winter steelhead, as well as other species and life stages. Water flowing into the entrance of the floating structure attracts juvenile fish. The fish enter and are held for transport around the dam by truck or barge or guided into a pipe that safely carries them downstream of the dam.

Capture structures that rely on gravity flows (and may also utilize supplemental pumped flow) are called Floating Screen Structures (FSS). Capture structures that utilize only pumped flow are called Floating Surface Collectors (FSC). Both types floating structures typically consist of large barges attached to vertical tracks on WTC towers that allow the structure to rise and fall with the reservoir (Figure 2.3-11).

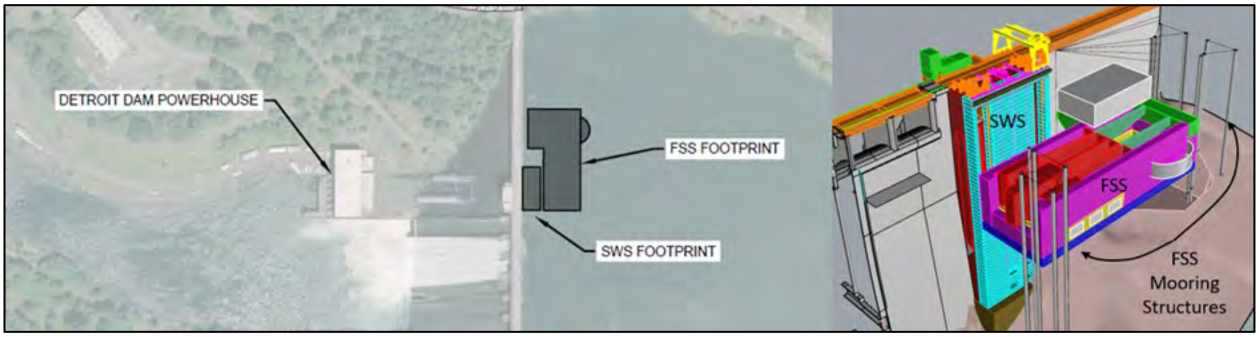


**Figure 2.2-11. Proposed Detroit Water Control Tower with Attached Floating Screen Structure**

The construction approach, feasibility, and design of the FSSs or FSCs would be site-dependent and would be determined during the construction design phase. Existing examples of FSS/FSCs have shown that consistent flows result in higher collection efficiency (Kock et all., 2019).

Adaptive management would be used to inform how to operate for hydropower and collection efficiency at these locations. The proposed Detroit Dam downstream passage facility (documented in the Detroit Downstream Passage Draft EIS [USACE, 2019b]) would be used for modeling and analyzing effects of the measure for Detroit Dam. Available design concepts for other locations, including Detroit and Cougar Dams, would be adapted to model and analyze effects for those locations. The flow range that would attract fish through each passage structure are shown in Table 2.3-9.

**Table 2.2-9. Minimum and Maximum Flows Floating Screen Structure by Project**

| Project | Minimum Flow1 (cfs) | Maximum Flow (cfs)2 |
|---|---|---|
| Detroit | 1,050 | 5,600 |
| Green Peter | 300- 1,000[3] | 5,300 |
| Cougar | 300 | 1,000 |
| Lookout Point | 1,350 | 6,000 |
| Hills Creek | 300 | 1,000 |

[1]Minimum flow is the minimum dam discharge.

[2] cfs = cubic feet per second

[3] At Green Peter Dam, the minimum dam discharge is 300-500 cfs, but can be supplemented with pumped flow up to 1,000 cfs.

### *2.2.3.4.2 Structural Downstream Fish Passage at Foster Dam*

Spillways can be the safest route for juvenile fish to pass a dam, but the spillway may be difficult for the fish to find. Most salmon and steelhead juveniles like to stay in the top 20 feet of the water column. Spillway openings may be as much as 60 feet below the surface, too deep for the fish to use.

At the Foster Dam, the spillway has been equipped with a spillway weir, a movable gate on the upriver side. When juvenile fish are migrating, water flows over the top of the weir and out through the spill gate. Since fish do not have to dive down to find the spillway entrance, more fish could pass with less water spilled. And since the fish quickly find passage, they also may escape predators above the dam. However, currently the Foster Dam spillway weir does not efficiently pass fish downstream.

Under this measure, the Foster Dam fish weir would be modified to improve downstream passage. The approach, feasibility, and design of the structure would be determined during the construction design phase. The design would utilize a flow rate of 500-800 cfs. Table 2.2-10 shows assumptions used for this measure at the Foster Dam.

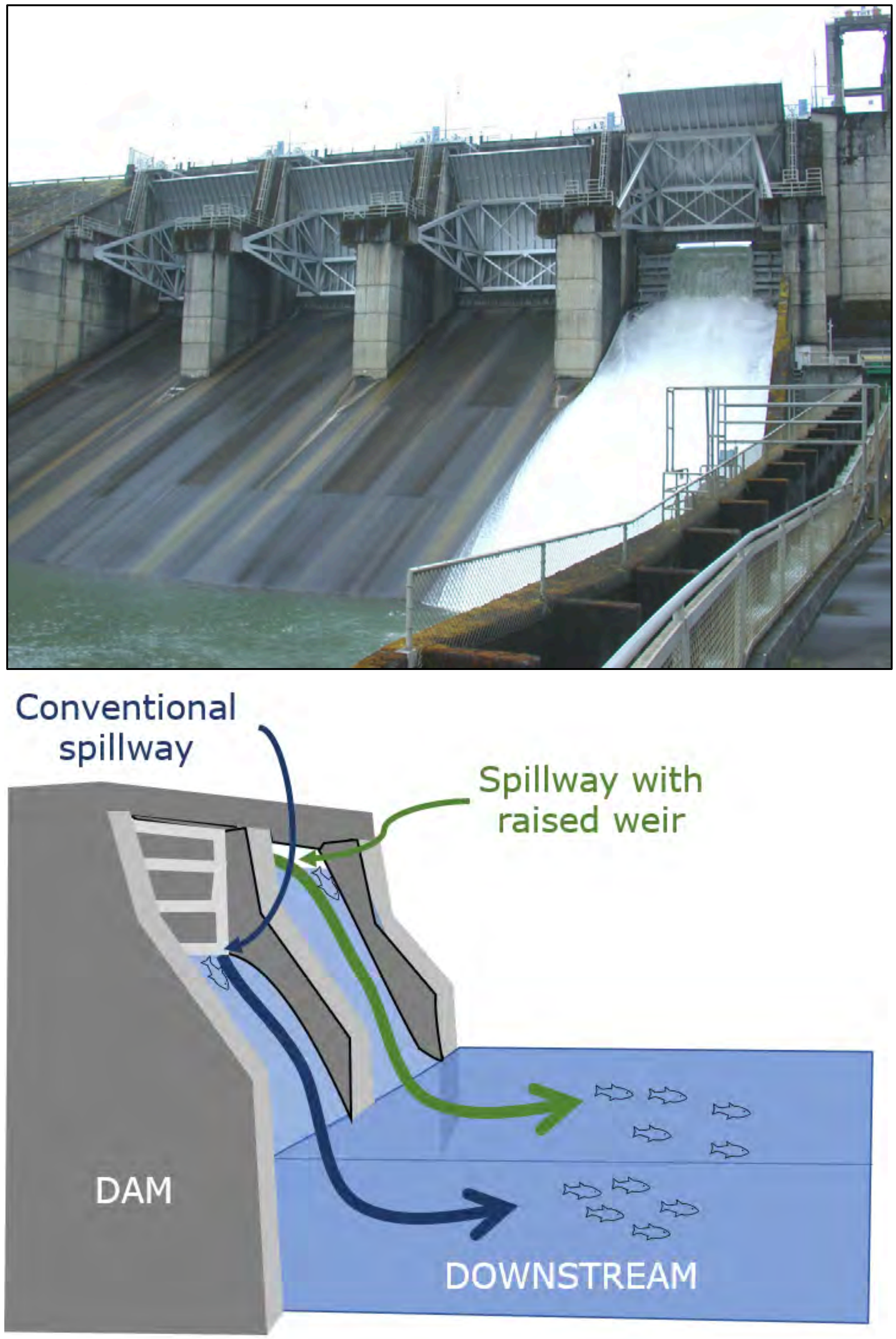


**Figure 2.2-12. Foster Dam's Fish Weir**

**Table 2.2-10. Assumptions used for the Downstream Passage Measure at Foster Dam**

| Category | Description |
|---|---|
| Description of work | Improve structural passage at Foster Dam |
| Duration (hours/days) | Fish structure operates all day, year-round at 600 cfs |
| Estimated Annual Start Date (day/month) | Year-round |
| Recurrence Interval (years) | Annually when the pool is within the operating elevation (winter at 615 feet min and summer at 635 feet max) |
| Pool Elevation (feet) | Foster Spillway: 615 (min elevation) to 635 (max elevation) |
| Restricted Outlet (RO/spillway/etc.) | Turbines restricted between 7:00 p.m. – 7:00 a.m. during fish passage seasons |
| Estimated Day/Month Start | When within operating range |
| Duration of Outlet Restriction (days) | When within operating range |
| Maximum Flow (cfs) | 800 cfs |

cfs = cubic feet per second

### 2.2.4 Upstream Fish Passage Measures

Adult salmon migrate from the ocean to spawn in freshwater, migrating upstream to the river where they were hatched. Dams and other structures across the river, block this upstream migration unless passage is provided.

The most common way for adult fish to get past a dam is to use a fish ladder, a water-filled structure that allows fish to pass up and over in a series of steps. Migrating salmon are attracted to the current at the base of an extended concrete stairway. The fish swim or jump from step to step. However, due to the height of the WVS high-head dams (between 93 feet and 463 feet tall), fish ladders are not practical. Where ladders are not practical, a trap and haul operation can be used to move adult fish upstream.

In trap and haul operations, migrating salmon are attracted to flow at the base of a fish ladder. They climb the ladder to a loading system where they wait in pools or tanks before transfer into specialized tankers or barges. These vehicles release the salmon into the river on the other side of the dam. This section describes the structural and operational measures to address upstream passage. Details specific to each basin/reservoir are provided where appropriate.

#### *2.2.4.1 Provide Pacific Lamprey Passage and Infrastructure (#52)*

Lamprey swim differently than salmon; passage facilities built for salmon present a difficult obstacle for this species. Square corners in the ladders are particularly difficult for lamprey. Lamprey will grab onto a vertical or horizontal surface then release, burst ahead, and grab on again in a near, up-ladder location. As they creep along in this way, they can lose their grip and be washed down the ladder.

Under this measure, structural features and modifications would be made at adult fish passage facilities to improve Pacific lamprey passage. Features and modification could include rounded corners in turning pools, rounded side edges of the ladder opening, replacement of diffuser screens[16] with lamprey-friendly screens, and other nature-based features.

Any new adult fish facilities (see measure #722) or facility modifications and upgrades, including at the drop structures under measures #639 below, would include these types of features to benefit lamprey.

Site-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared when this measure is implemented.

#### *2.2.4.2 Restore Upstream and Downstream Passage at Drop Structures (#639)*

A drop structure, also known as a low head dam, grade control, sill, or weir, is a manmade structure, typically small and built on minor streams, to pass water to a lower elevation while controlling the energy and velocity of the water as it passes over. Unlike most dams, drop structures are usually not built for water impoundment, diversion or raising the water level. Drop structures are built to control the velocity and energy of water as it flows from higher to lower elevation and can also help control erosion (Figure 2.3-14). However, drop structures are nearly impossible for fish to traverse if they were constructed without fish passage measures.

Under this measure, infrastructure would be improved downstream of the Fern Ridge Dam at Monroe, Stroda, and Cox Butte drop structures to provide improved fish passage. This measure is intended to provide passage for fish, including juvenile UWR spring Chinook salmon and other aquatic organisms, to the mainstem Long Tom River and tributaries between the confluence with the Willamette River and Fern Ridge Dam.

Infrastructure improvements could include installation of fish ladders, notching or other direct modifications to drop structures, installation of bypass channels, or dam removal and replacement with riffle and pool systems. These improvements would include design features to provide Pacific lamprey passage as described in Section 2.3.4.1 under Measure #53. Site-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared for construction to restore passage at drop structures.

#### *2.2.4.3 Construct Adult Fish Facility (#722)*

This measure would include the construction of new adult fish facilities, like the one at Cougar Dam (Figure 2.3-15), and at Green Peter, Hills Creek, and Blue River Dams. These facilities would be designed with the flexibility to provide adequate water supply, provide normative

[16] A diffuser is a system of hydraulic components arranged to control water flow rate and convert high-velocity, high-pressure, non-uniform flow into low-energy, uniform flow to attract fish. A diffuser screen or grate also includes one or more panels of narrowly spaced horizontal or vertical bars to prevent fish from passing through the bars and entering the area upstream of the panels.

temperatures in the fish ladder, and attract upstream migrant fish in a timely manner during the spring.

The approach and design of the facility and/or upgrades would be determined during the construction design phase. Site-specific design and environmental compliance documentation would be prepared for construction of each new adult fish facility (Chapter 7).

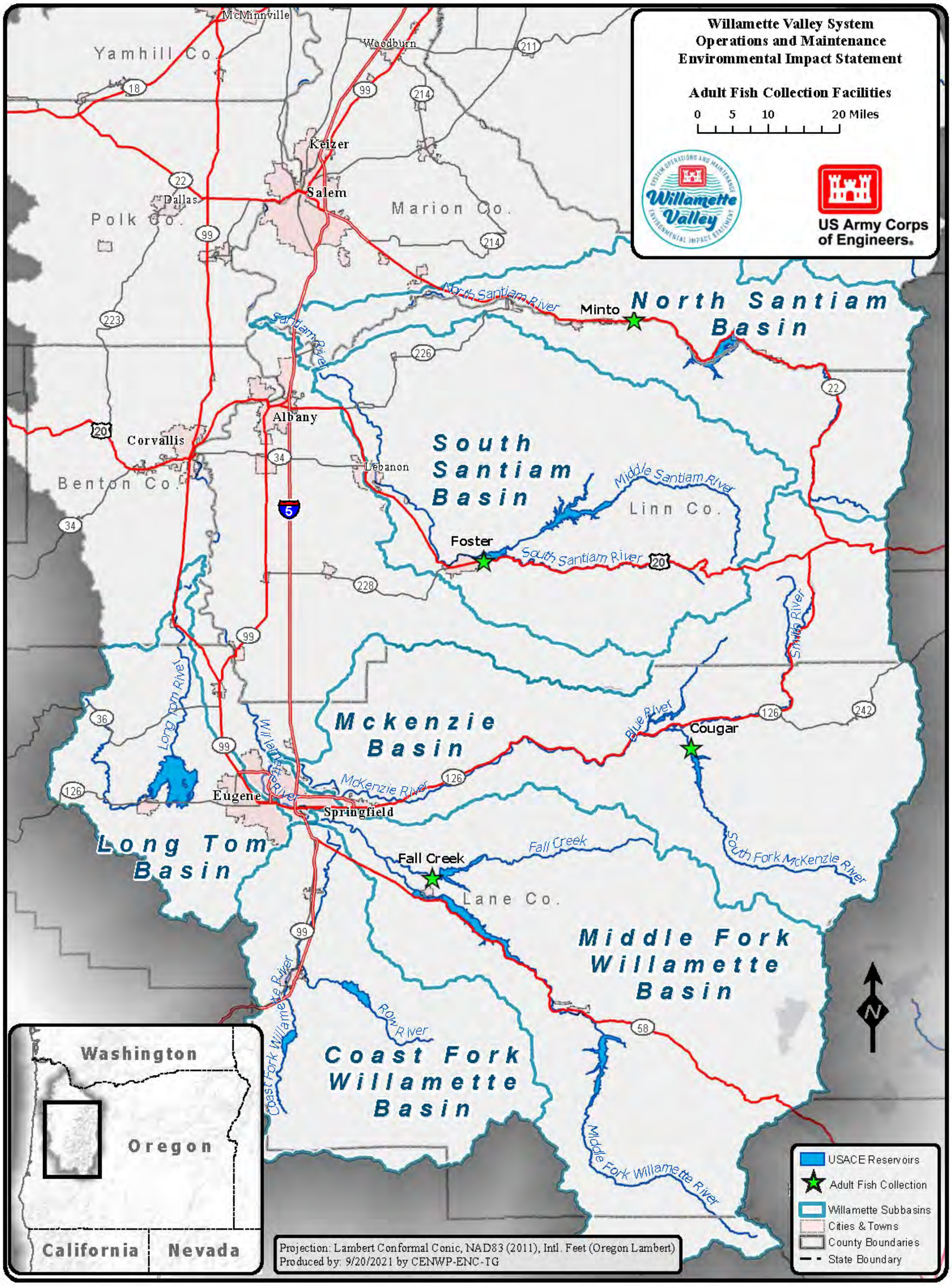


**Figure 2.2-13. USACE Existing Adult Fish Collection Facilities in the WRB**

**Figure 2.2-14. Drop Structure Downstream of the Fern Ridge Dam**

**Figure 2.2-15. Fish Ladder at the Cougar Adult Fish Collection Facility**

### 2.2.5 Suite of Near-term Operations

USACE is evaluating a suite of operations like the injunction operations ordered by the District Court in *Northwest Environmental Defense Center, et al. v. United States Army Corps of Engineers, et al.,* No. 3:18-cv-00437-HZ, (D. Or. September 2021). The operations would be conducted until the structural measures in the selected alternative supersede or replace the operations. The operations, modeled after the injunction, have been slightly refined through adaptive management (AM) during implementation.

A short description of the near-term operations in the measures including location, timing, outlet priorities for use to release flow through the dam, and target elevations of the reservoirs are listed in Table 2.3-11. Details for each of these operations are provided in Appendix A.

**Table 2.2-11. Suite of Near-term Operations**

| Description of Near-term Operations by Location | Duration of Operation | Priority Outlet | Target Elevation |
|---|---|---|---|
| **Detroit** | | | |
| Spring downstream fish passage and operational downstream temperature management | mid-Mar to Fall | Spillway/ Turbines/ ROs | n/a |
| Nighttime RO prioritization for improved downstream fish passage | Winter | Upper ROs/ Lower ROs | Less than 1,500 feet |
| Big Cliff | | | |
| Spread spill across spillbays to reduce downstream TDG exceedances | Year-round | Spillway | Discharges greater than Powerhouse Capacity |
| Green Peter | | | |
| Outplanting plan for reintroduction of adult Chinook salmon above Green Peter Dam | Summer | n/a | n/a |
| Utilize spillway for improved downstream fish passage in the spring; perform spill operation until May 1 or for 30 days, whichever is longer | mid-Mar to May/Jun | Spillway | Greater than 971 feet (spillway crest) |
| Deep drawdown and RO prioritization for improved downstream fish passage | Early Sep to mid-Dec | RO | 780 feet |
| Foster | | | |
| Delay refill and utilize spillway in the spring for improved downstream fish passage; use the fish weir in the | Feb 1 to Jun 15; Jun 16 to approximately | Spillway (spring) | 613 feet (Feb - May)<br>637 feet (May - Jul) |

| Description of Near-term Operations by Location | Duration of Operation | Priority Outlet | Target Elevation |
|---|---|---|---|
| summer for improved downstream temperature management and upstream fish migration/passage | late-Jul (similar to NAA described in Section 2.5.1.3) | Fish Weir (summer) | |
| Utilize the spillway for improved downstream fish passage in the fall | Oct 1 to Dec 5 | Spillway | 613 feet |
| Cougar | | | |
| Deep drawdown and RO prioritization for improved downstream fish passage | Early Nov to Dec 15 | RO | 1,505 feet |
| Delayed reservoir refill and RO prioritization for improved downstream fish passage | Feb to May/Jun | RO | 1,520-1,532 feet |
| Hills Creek | | | |
| Nighttime RO prioritization for improved downstream fish passage | Approximately Nov to Mar | RO | Less than 1,460 feet |
| Lookout Point | | | |
| Utilize spillway for improved downstream fish passage in the spring; RO use in the fall for downstream temperature management | mid-Mar to May/Jun (spring);<br>Jul to Oct 15 (RO) | Spillway/RO | 890 to 893 feet spring spill<br><br>Less than 887.5 feet late summer/ fall RO |
| Deep drawdown and RO prioritization for improved downstream fish passage | Nov 15 to Dec 15 | RO | 750 feet |
| Fall Creek | | | |
| Extended deep drawdown and RO prioritization for improved downstream fish passage | Dec 1 to Jan 15 | RO | 685 to 690 feet |
| Delayed reservoir refill and RO prioritization for improved downstream fish passage | Jan to Mar 16;<br>Mar 16 to May 15 | RO | 700 feet; 728 feet |

These operations are designed to improve fish passage and water quality until the structural measures under an alternative can be implemented. The duration of a near-term operation at a specific location would depend on the implementation order of the structural measures under the alternative.

Structural measures require additional design, site-specific NEPA evaluation, permitting, planning, construction, etc. delaying implementation. The effects of the near-term operations are analyzed for the 30-year temporal span of the WVS PEIS ensuring impacts from the operations are analyzed because duration of an operation at a particular location is uncertain. The implementation timeline for the construction of structural measures under the Preferred Alternative and the duration of these operations under that alternative are described in Chapter 5.

USACE would comply with NEPA and other environmental compliance requirements if operations are modified through the AM process.

### 2.2.6 General Construction Activities Common to All Alternatives

Measures described above in Section 2.2 would be applied programmatically under any alternative. Each would require construction activities; however, details of these activities are largely unknown at this time. Limited analyses and a range of potential effects of general construction activities are included in the effects analysis for each resource in Chapter 3 of this PEIS in the methodology description for each resource area.

Although site-specific design and construction are not yet available, descriptions of general activities that could occur during implementation of the measures under any alternative are summarized below. Measure numbers correspond to measure descriptions above. The following subsections provide a summary of the anticipated construction needed for specific measures.

#### *2.2.6.1 Construct WTC Tower (#105)*

Construction of a WTC tower at a high head dam like Detroit would require an intake tower to be built in the reservoir that can pass water from multiple elevations between the minimum pool and maximum pool. The tower can be constructed out of steel or concrete.

The Cougar Dam temperature control tower was built in dry conditions (i.e., in-the-dry) out of concrete by using the diversion tunnel to lower the reservoir. The concrete tower was then built using traditional concrete construction methods like slip forming.

A WTC tower at Shasta Dam in California was built out of steel in wet conditions (i.e., in-the-wet) by constructing steel modules off site, lowering the modules into position with a crane, and then attaching them to the face of the dam using divers.

A Design Decision Document was complete for Detroit Temperature Control that proposes to build the tower out of concrete in-the-wet using pre-cast concrete modules. This would involve dredging the forebay to make room for the foundation, placing a concrete foundation that is level, and then using a large crane to place the pre-cast concrete modules on top of the foundation. After the concrete is in position, the mechanical and electrical features would be installed, and the tower would be plumbed into the existing dam outlets. Construction of a WTC tower would take 3 to 5 years.

#### *2.2.6.2 Foster Fish Ladder Temperature Improvement (#479)*

Temperature control at Foster Dam is currently targeting a narrow range of forebay elevations so a full height intake tower is not required. A smaller intake structure is being proposed at Foster Dam that would pass warm water during the spring and summer months. Construction would involve boring a hole through Foster Dam, attaching the prefabricated intake structure to the face of the dam using barge mounted cranes, and then installing the mechanical and electrical systems. This is expected to take 3 years to construct.

#### *2.2.6.3 Use Spillways for Surface Spill in Summer (#721) Only at Hills Creek and Blue River Dams*

The spillway at Hills Creek and Blue River Dams would require civil and structural improvements to be used on a regular basis. Hydraulic excavators would be used to excavate and regrade the spillway channel back to the river and then concrete would be placed to armor the channel. A cofferdam may be required at the bottom of the spillway channel to place concrete below ordinary high water. This work is expected to take 1 to 2 years.

#### *2.2.6.4 Structural Improvements to Reduce TDG (#174)*

TDG improvements are at a conceptual design level. A possible method is to place concrete structures in the tail race (e.g., baffle blocks - several identical structures arranged in one or several rows orientated perpendicular to the direction of flow).

Construction would involve building a cofferdam during the summer low flow and in-water-work period, excavating for a foundation, potentially drilling into the bedrock and embedding rebar dowels, placing concrete, and then removing the cofferdam. Construction can only take place during the summer when flows are low. Depending on the quantity of concrete structures to be placed and how far apart they are spaced, it could take multiple seasons to complete all the structures at a dam.

#### *2.2.6.5 Deeper Fall Reservoir Drawdowns for Downstream Fish Passage (#40) Only at Cougar Dam for the Drawdown Operation to the DT*

An intake and access tower would need to be constructed at Cougar Dam to use the diversion tunnel as a routine outlet. Construction of the tower would require an extended deep drawdown of Cougar reservoir and a cofferdam around the diversion tunnel intake so that concrete placement can be completed in-the-dry. The concrete tower would be constructed by equipment staged on barges in the reservoir.

Multiple seasons of deep drawdowns would be required to get the tower to full height. Once the concrete placement is complete, the mechanical and electrical systems would be installed. Construction is expected to take 5 years.

#### *2.2.6.6 Construct Structural Downstream Fish Passage (#392)*

Floating surface collectors (FSCs) and floating screen structures (FSSs) are largely built off-site at a metal fabrication shop in modules that are as large as possible but can still be trucked to the shoreline of a reservoir. A staging area along the shore of the reservoir would be identified, typically at an existing boat ramp. The facility would be assembled at the staging area with as much mechanical testing and commissioning completed as possible prior to launching the facility. Once complete, the facility would be launched into the water by driving, pushing, or rolling it down the hill. It would then be towed into position by tugs and anchored in place. Construction of a downstream passage structure would take 2 to 3 years.

Structural downstream passage at Foster Dam would not be provided by an FSC or FSS. At the Foster Dam, an existing surface route structure (fish weir) would be modified to improve downstream passage. Construction of the gate modification would require taking the gate out of service for several months.

Access platforms would be constructed around the concrete piers and a crane would be staged on top the dam. The road over the dam would have to be closed to for several months. Structural, mechanical, and electrical work would be completed on the gate. All work would be completed in-the-dry. This is expected to take 1 year to complete.

#### *2.2.6.7 Pass Water over Spillway in Spring for Downstream Fish Passage (#714) Only at Hills Creek Dam*

The spillway at Hills Creek Dam would require civil and structural improvements to be used on a regular basis. Hydraulic excavators would be used to excavate and regrade the spillway channel back to the river and then concrete would be placed to armor the channel. A cofferdam may be required at the bottom of the spillway channel to place concrete below ordinary high water. This work is expected to take 1 to 2 years.

#### *2.2.6.8 Spring Reservoir Drawdown for Downstream Fish Passage (#720) Only at Cougar Dam for the Drawdown Operation to the DT*

An intake and access tower would need to be constructed at Cougar Dam to use the diversion tunnel as a routine outlet. Construction of the tower would require an extended deep drawdown of Cougar reservoir and a cofferdam around the diversion tunnel intake so that concrete placement can be completed in-the-dry. The concrete tower would be constructed by equipment staged on barges in the reservoir.

Multiple seasons of deep drawdowns would be required to get the tower to full height. Once the concrete placement is complete, the mechanical and electrical systems would be installed. Construction is expected to take 5 years.

#### *2.2.6.9 Provide Pacific Lamprey Passage and Infrastructure (#52)*

Lamprey passage measures are typically incorporated into an upstream fish passage structure. It would consist of minor modifications that help lamprey navigate up the ladder. For example, metal strips would be welded to diffuser grating, also known as a diffuser screen, so that there is a continuous strip of metal for lamprey suction (Section 2.2.4.1). Construction would require the fish ladder to be dewatered to provide access. It would take a few months to complete the modifications.

#### *2.2.6.10 Restore Upstream and Downstream Passage at Drop Structures (#639)*

There are several versions of fish ladders that can provide passage for fish over drop structures. The simplest version would be to use stones and gravel to create a series of pools for fish navigation. On the robust end of the spectrum, a concrete fish ladder would be constructed. Construction would involve using hydraulic excavators to regrade the ladder area and then placing necessary building materials into the area. These structures typically do not have any mechanical or electrical features. A temporary cofferdam is likely required to dewater the construction area. It would take several months to 1 year to complete.

#### *2.2.6.11 Construct Adult Fish Facility (#722)*

Upstream passage at WVS dams involves building a trap and haul facility similar to those recently built at Cougar, Minto, Foster, and Fall Creek Dams. The facility would be built on the bank of the river immediate downstream of a structure that prevents the fish from swimming upstream.

Construction would involve building a cofferdam along the bank so that the water intake and fish ladder entrance can be built below ordinary high water. The fish ladder would bring the fish upland to a presort pool. Fish would then be processed through the sorting area, post sort pools, and then loaded into trucks and transported above the dam. This would require earthwork, concrete placement, in-water-work, mechanical, and electrical work. Construction of an upstream passage facility would typically take 2 to 3 years.

#### *2.2.6.12 Gravel Augmentation (#384)*

Gravel augmentation would involve use of an existing road to the riverbank, backing a dump truck full of gravel down the bank, and dumping the gravel in the river. Placing a dump truck load of gravel would takes a few hours.

#### *2.2.6.13 Maintain Revetments considering Nature-based Engineering or Alter Revetment for Aquatic Ecosystem Restoration (#9)*

This work would involve using a hydraulic excavator to maintain the revetment using natural materials. The work would not require a cofferdam but would be performed during the in-water-work period.

Maintenance of a revetment would take about 1 week. Altering revetments for aquatic ecosystem restoration could require more extensive work that could take up to several months during the in-water-work period over 1 or more years.

#### *2.2.6.14 Maintenance of Existing and New Fish Release Sites above Dams (#726)*

Some proposed sites may require minor improvements consisting of minor grading or occasion tree removal.

#### *2.2.6.15 Major Maintenance and Rehabilitation Sequencing and Timing*

As discussed in Section 1.8.7.2, the timing, duration, and extent of non-routine major maintenance are unforeseeable. The type of construction activities required would be unique to each maintenance requirement and cannot be predicted. Each action would be routinely assessed for environmental compliance prior to implementation.

## 2.3 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED STUDY

As noted above, measures were combined to form distinct alternatives with a particular management strategy. A stand-alone hydropower alternative was determined not to be distinctive enough from other action alternatives being considered and was, therefore, eliminated from further consideration. After development of the alternatives and identification of measures to be implemented under each of the alternatives, USACE determined that a stand-alone hydropower alternative was not necessary because measures that would benefit hydropower production were integrated into other action alternatives.

## 2.4 ALTERNATIVES CONSIDERED IN DETAIL

The following sections describe the alternatives evaluated in detail in this PEIS, including the NAA. All the action alternatives described below would meet the USACE proposed action to continue operation and maintenance of the WVS for specific, authorized purposes and in compliance with the ESA and all other applicable treaties, laws, and regulations (Section 1.3).

The measures outlined in Section 2.2 are incorporated under each alternative as applicable. Summary tables of the measures incorporated into an alternative are provided at the end of each alternative description.

A summary table comparing measures under each alternative is provided at the end of this chapter (Table 2.4-14).

### 2.4.1 No Action Alternative

The NAA is required by NEPA (40 CFR §1502.14) to provide the existing condition of the analysis area and O&M for comparison of environmental effects of the action alternatives. The NAA consists of the current projects within the WVS and the conditions that would result from continued O&M and configuration of the WVS under existing management, prior to the initiation of this Draft PEIS, with no change.

All ongoing, scheduled, and routine maintenance actions for the USACE-managed infrastructure in the WRB and all USACE-managed structural features, including those recently constructed or that were reasonably foreseeable at the beginning of this Draft PEIS effort, are included under the NAA. Actions and operations occurring in the WVS include those agreed to in previous ESA consultations between USACE and the Services.

This alternative does not meet the full purpose and need of the project because the current operating conditions of the WVS do not adequately protect ESA-listed fish species, specifically UWR spring Chinook salmon and UWR winter steelhead or designated critical habitat for these species.

The NAA consists of the O&M of the WVS as they stood in April 2019 when USACE issued the Notice of Intent to prepare a Draft PEIS. The hydrology dataset, information on waters within the WVS, was used as input for the Draft PEIS reservoir regulation model and was developed in 2018, the year prior to when modeling of the NAA began. The April 2019 date was selected to provide a clear set of operations to analyze and compare alternatives, given the length of time needed to complete a draft PEIS and several temporary operational changes that were shifting throughout the process due to the temporary dam safety operations and litigation, discussed in Sections 1.9.2 and 1.9.3, respectively.

Each of the 13 dams and reservoirs within the WVS are operated according to a water control manual that is authorized by Engineering Regulation 1110-2-240. These manuals provide specific information to meet the congressionally authorized purposes of FRM, generation of hydropower, water supply, irrigation, navigation, recreation, and fish and wildlife (Section 1.7). The manuals also detail operations, procedures, and rule curves for each project. The operations evaluated in the NAA follow these manuals with minor changes that have been made in response to changes in WRB conditions and new information related to system operations and technology, the affected environment, polices, and regulations such as the ESA.

Measures analyzed as part for of the NAA are described further in this section. **Error! Reference source not found.**Table 2.4-1 lists these measures and identifies the locations where they occur.

**Table 2.4-1. No Action Alternative Measures and Locations**

| MEASURE | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WATER QUALITY OPERATIONS** | – | – | – | – | – | – | – | – | – | – | – | – | – |

| MEASURE | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Use spillway to release warm surface water to manage downstream temperatures | – | – | – | – | – | – | – | – | – | X | – | – | X |
| Strategic use of outlets to meet temperature targets when possible | – | – | – | – | – | X | – | – | – | – | – | – | – |
| WTC Tower operation to manage downstream temperatures | – | – | – | – | – | – | – | X | – | – | – | – | – |
| Spread spill across spillbays to reduce TDG | – | – | – | X | – | – | – | – | – | – | – | X | – |
| Discharge water through the powerhouse to reduce/dilute the TDG generated from use of the spillways or ROs | – | – | – | X | X | – | X | X | – | X | X | X | X |
| **FLOW OPERATIONS** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 2008 NMFS BiOp Targets | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Augment flows using the inactive or power pool | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **DOWNSTREAM PASSAGE OPERATIONS** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Pass fish over spillway | – | – | – | – | – | – | – | – | – | X | – | – | – |
| Drawdown to pass fish through RO (lowest outlet) | – | – | – | – | – | X | – | – | – | – | – | – | – |
| **UPSTREAM PASSAGE OPERATIONS** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Continued operation and maintenance of existing adult fish facility | – | – | – | X | – | X | – | X | – | X | – | X | – |

#### *2.4.1.1 Stream Flow*

Under the NAA, USACE would continue to use the water control annual planning process described in Section 1.8.3. This planning process would determine how the authorized project purposes would be accomplished during the conservation season based on the water supply forecast and the 2008 NMFS BiOp targets.

Operational flow targets at Salem would continue to be set on April 1, based on a storage forecast (e.g., adequate, insufficient) for mid-May (May 10 to May 20). Mainstem flow targets for adequate and abundant water years are listed in Table 2.4-2, and the tributary flow targets are provided in Table 2.4-3.

Water from the power pool at Green Peter Reservoir would continue to be used on an as needed basis, depending on hydrologic conditions, to augment flow in the South Santiam sub-basin and mainstem Willamette River.

**Table 2.4-2. Mainstem Willamette Flow Objectives**

| Time Period | 7-Day Moving Average 2 Minimum Flow at Salem (cfs) 3 USGS 141910004 | Instantaneous Minimum Flow at Salem (cfs) 3 USGS 141910004 | Minimum Flow at Albany (cfs) 3 USGS 141740005 |
|---|---|---|---|
| April 1 - 30 | 17,800 | 14,300 | – |
| May 1 - 31 | 15,000 | 12,000 | – |
| June 1 - 15 | 13,000 | 10,500 | 4,500 3 |
| June 16 - 30 | 8,700 | 7,000 | 4,500 3 |
| July 1 - 31 | – | 6,000 3 | 4,500 3 |
| August 1 - 15 | – | 6,000 3 | 5,000 3 |
| August 16 - 31 | – | 6,500 3 | 5,000 3 |
| September 1 - 30 | – | 7,000 3 | 5,000 3 |
| October 1 - 31 | – | 7,000 | 5,000 |

[1] Appendix D defines “Adequate” and “Abundant” water years, and also describes how flow objectives can be decreased in “Deficit” water years.

[2] An average of the mean daily flows in cubic feet per second (cfs) observed over the prior 7-day period.

[3] Congressionally authorized minimum flows (HD 531). September flows were extended into October.

[4] USGS gage 14191000 Willamette River at Salem, OR

[5] USGS gage 14174000 Willamette River at Albany, OR

**Table 2.4-3. Minimum and Maximum Tributary Flow Objectives**

| Dam | Period | Primary Use | Minimum Flow (cfs)1 | Maximum Flow (cfs)2 |
|---|---|---|---|---|
| Hills Creek | Sep 1 - Jan 31 | Migration & rearing | 400 | – |
| | Feb 1 - Aug 31 | Rearing | 400 | – |
| Fall Creek | Sep 1 - Oct 15 | UWR Chinook salmon spawning | 200 | 400 through Sep 30, when possible |
| | Oct 16 - Jan 31 | UWR Chinook salmon incubation | 50[3] | – |
| | Feb 1 - Mar 31 | Rearing | 50 | – |
| | Apr 1 - May 31 | Rearing | 80 | – |
| | Jun 1 - Jun 30 | Rearing/adult migration | 80 | – |
| | Jul 1 - Aug 31 | Rearing | 80 | – |

| Dam | Period | Primary Use | Minimum Flow (cfs)1 | Maximum Flow (cfs)2 |
|---|---|---|---|---|
| Dexter | Sep 1 - Oct 15 | UWR Chinook salmon spawning | 1,200 | 3,500 through Sep 30, when possible |
| | Oct 16 – Jan 31 | UWR Chinook salmon | 1,200[3] | – |
| | Feb 1 – June | Rearing | 1,200 | – |
| | Jul 1 – Aug 31 | Rearing | 1,200 | – |
| Big Cliff | Sep 1 – Oct 15 | UWR Chinook salmon spawning | 1,500 | 3,000 through Sep 30, when possible |
| | Oct 16 – Jan 31 | UWR Chinook salmon | 1,200[3] | – |
| | Feb 1 – Mar 15 | Rearing/adult | 1,000 | – |
| | Mar 16 – May | UWR Steelhead | 1,500 | 3,000 |
| | Jun 1 – Jul 15 | UWR Steelhead | 1,200[3] | – |
| | Jul 16 – Aug | Rearing | 1,000 | |
| Foster | Sep 1 – Oct 15 | UWR Chinook salmon spawning | 1,500 | 3,000 through Sep 30, when possible |
| | Oct 16 – Jan 31 | UWR Chinook salmon | 1,100[3] | – |
| | Feb 1 – Mar 15 | Rearing | 800 | – |
| | Mar 16 – May | UWR Steelhead | 1,500 | 3,000 |
| | May 16 – Jun | UWR Steelhead | 1,100[3] | – |
| | Jul 1 – Aug 31 | Rearing | 800 | – |
| Blue River | Sep 1 – Oct 15 | UWR Chinook salmon spawning | 50 | – |
| | Oct 16 – Jan 31 | UWR Chinook salmon | 50 | – |
| | Feb 1 – Aug 31 | Rearing | 50 | – |
| Cougar | Sep 1 – Oct 15 | UWR Chinook salmon spawning | 300 | 580 through Sep 30, when possible |
| | Oct 16 – Jan 31 | UWR Chinook salmon | 300 | – |
| | Feb 1 – May | Rearing | 300 | – |
| | Jun 1 – Jun 30 | Rearing/adult | 400 | – |
| | Jul 1 – Jul 31 | Rearing | 300 | – |
| | Aug 1 – Aug 30 | Rearing | 300 | – |

[1] When a reservoir is at or below minimum conservation pool elevation, the minimum outflow will equal inflow or the Congressionally authorized minimum flows, whichever is higher.

[2] Maximum flows are intended to minimize the potential for spawning to occur in stream areas that might subsequently be dewatered at the specified minimum flow during incubation.

[3] USACE will attempt to avoid prolonged releases in excess of the recommended maximum spawning season discharge to avoid spawning in areas that would require high incubation flows that would be difficult to achieve and maintain throughout the incubation period. When maximum flow objectives are exceeded for a period of 72 hours or longer, the WATER Flow Management Committee will review available monitoring information (e.g.,

regarding redd deposition in relation to flow rates), projected runoff, and reservoir storage, and will formulate a recommendation for an appropriate and sustainable incubation flow rate prior to the initiation of the subsequent incubation period.

### *2.4.1.2 Water Quality*

Under the NAA, water quality management objectives in the WVS would continue to include control of instream water temperature and reduction in TDG concentrations in river reaches below WVS dams as described below.

#### *2.4.1.2.1 Temperature Control*

There are no water temperature goals set for the WVS at Salem. The focus, instead, would be on in-tributary conditions (directly downstream of USACE dams) where spawning, rearing, and incubation of ESA-listed anadromous fish occurs. Table 2.5-4 shows the operational temperature management strategies that would continue to be implemented under the NAA to improve in-tributary conditions.

**Table 2.4-4. Operational Temperature Management Strategies at Projects**

| Dam | Strategy |
|---|---|
| Cougar | WTC tower operated to aid in meeting downstream water temperature goals for the purpose of ESA-listed species. Cougar Dam is the only project in the WVS with selective withdrawal capabilities to manage downstream water temperatures. |
| Detroit | Downstream temperature control starts June 1 or as soon as reservoir reaches spillway after June 1 by blending flow released over the spillway with flow released through the upper ROs or through turbines. Mixing takes place in Big Cliff Reservoir before water is passed downstream through Big Cliff Dam. |
| Fall Creek | Operational water temperature is informally conducted through a combination of fish horns and ROs. The main objective for the Fall Creek temperature management is to attract adult fish back to the fish facility located at the base of Fall Creek Dam. |
| Foster | The Foster fish weir is used during approximately June 15 through approximately July 30 annually as an operation to pass warm surface water from the reservoir to increase the river temperatures downstream. This operation is conducted to improve adult salmon collection at the Foster Adult Fish Facility. Without this fish weir operation, the river downstream of Foster Dam remains cold and creates a temperature block for returning adult salmon; that is, returning adult salmon remain downstream instead of returning to the Adult Fish Facility. The warm surface flow from the fish weir blends with the river downstream creating ideal water temperatures to attract adult salmon back to the Adult Fish Facility. |

#### *2.4.1.2.2 Total Dissolved Gas*

The amount of TDG generated through dam operations is highly dependent on the amount of water discharged, the dam outlets used to pass water, and the water temperatures observed during a particular operation. To reduce high levels of TDG, the general operating guidance under the NAA would be as follows:

- Discharge water through the powerhouse to reduce/dilute the TDG generated from use of the spillways or ROs.
- Under high flows, distribute the discharge over as many spill bays as possible with a uniform pattern, rather than putting all discharge through one bay.
- TDG generated at the high-head peaking projects would likely decrease before being passed through the downstream re-regulating dam. USACE would focus on using the powerhouse to further reduce/limit TDG from being passed downstream under the NAA.

### ***2.4.1.3 Downstream Fish Passage***

Under the NAA, there are two locations where downstream fish passage operations would occur. Although a surface outlet is available for fish to pass at other dams, the intent of these operations would be for temperature management.

Fall Creek Reservoir would be drawn down to its lowest outlet, elevation 690, for a few weeks in November lasting sometime into December. The actual operation would vary based on when fish are present and are passing. The analyses under the NAA considers this operation as a deep fall drawdown to elevation 690 from November 15th to December.

At Foster Reservoir fish pass downstream via the spillway. The analyses under the NAA considers this operation as releasing half of the flow over the spillway from March 16 through June 16 and then again from October 16 through December 16. Additionally, the NAA includes releasing 300 cfs over the spillway from June 16 through August 16.

### ***2.4.1.4 Upstream Passage (Adult Fish Facilities)***

Under the NAA, the adult fish facilities would continue to be operated and maintained in accordance with the Willamette Fish Operation Plan (WFOP), the operational plan noted in Section 1.8.8. The WFOP is developed annually by USACE in coordination with the BPA as well as regional federal, state, and Tribal fish agencies and other partners through the WFPOM coordination team.

Generally, adult fish collection facilities are operated annually between April and October. However, the WFOP describes year-round O&M activities of the adult fish collection facilities as coordinated through WFPOM to protect and enhance anadromous and resident fish species listed as endangered or threatened under the ESA, as well as non-listed species of concern, including Pacific lamprey. The WFOP guides USACE actions related to fish protection and passage at the 13 WVS projects.

#### *2.4.1.5 Willamette River Basin Bank Protection Program*

Under the NAA, when funding is available, USACE would continue to maintain and repair the USACE-maintained revetment projects in the WRB that were assessed in the 2013 hydraulic, hydrologic, and geomorphic investigation discussed in Section 1.6.1.

#### *2.4.1.6 Hatchery Program*

Under the NAA, the Hatchery Program would continue to be operated as described in Section 1.6.2.

#### *2.4.1.7 Hydropower Generation*

Under the NAA, hydropower generation would occur as described in Sections 1.7.2 and 1.8.4.

#### *2.4.1.8 Municipal and Industrial Water Use*

The NAA uses the 2050 M&I demand as estimated in the WBR (USACE, 2019). An important difference between the M&I values and the AI values is the estimated increase in withdrawals of live flow under existing water rights for M&I use. This PEIS uses estimates of increases in withdrawals of live flow between 2020 and 2050 from the WBR (USACE, 2019).

#### *2.4.1.9 Agricultural Irrigation Water Use*

Irrigation use in the WRB has not increased as initially projected and is not expected to increase in the future at levels near the scope and scale originally envisioned in the authorizing legislation for the projects. As of October 2022, there were 266 BOR Water Service Contracts for 82,815 acre-feet of water per year (approximately 5 percent of the conservation storage), which would be the NAA contract value.

At the current low level of use for water service contracts, USACE does not make special operational adjustments, such as increasing flow releases, to meet contract requirements at most projects, except for Fern Ridge and Detroit Dams. However, in deficit water years, the NMFS RPA requires BOR to curtail water contract diversions. In other years, the RPA requires USACE to release more than minimum flow to ensure the contract users do not take water intended for fish purposes from Fern Ridge and Detroit Dams. These conditions would remain in effect under the NAA.

In “deficit" water years, as defined in the 2008 NMFS BiOp, a partial water supply or no water supply may be available to satisfy some existing and new irrigation contracts. Water deliveries may be ceased or curtailed under these conditions, per RPA 3.4, under the NAA.

#### *2.4.1.10 Maintenance Operations*

Under the NAA, USACE would continue to implement a maintenance program at each WVS facility, consisting of routine inspection and maintenance of both power and non-power assets. USACE utilizes computerized maintenance management systems to plan, schedule, resource, and track this work.

##### *2.4.1.10.1 Scheduled/Routine Maintenance*

Under the NAA, routine maintenance would continue as described in Section 1.8.8.1.

##### *2.4.1.10.2 Major Maintenance and Rehabilitation*

Under the NAA, major maintenance and rehabilitation would occur as described in Section 1.8.7.

### 2.4.2 Measures Common to All Action Alternatives

Measures common to all action alternatives are those that would be implemented regardless of the action alternative selected. Measures common to all action alternatives include both operational measures and structural measures in multiple locations throughout the WVS. They also include new measures, existing operations, and O&M activities that would be carried forward. These measures, whether they are new or existing, and the locations where they would occur are shown in Table 2.5-5.

**Table 2.4-5. Measures and Locations Common to All Action Alternatives**

| Measure | New or Existing Measure | Action Location |
|---|---|---|
| Gravel Augmentation below Dams | New | North Santiam, South Santiam, and McKenzie River Basins below Big Cliff, Foster, Cougar, and Blue River Dams |
| Adapt Hatchery Program | New | North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins |
| Maintain Revetments considering Nature-based Engineering or Alter Revetments for Aquatic Ecosystem Restoration | New | Basin-wide |
| Maintenance of Existing and New Fish Release Sites above Dams | New | North Santiam, South Santiam, South Fork McKenzie, and Middle Fork Willamette sub-basins |
| Fall Creek Drawdown | Existing | Fall Creek |

| Measure | New or Existing Measure | Action Location |
|---|---|---|
| Operation and Maintenance of Existing Adult Fish Facilities | Existing | Dexter, Foster, Fall Creek, Minto (downstream of Big Cliff), and Cougar Dams |
| Operation, Maintenance, Repair, Replacement, and Rehabilitation | Existing | Basin-wide |

#### *2.4.2.1 Gravel Augmentation below Dams (#384)*

Under all action alternatives, improving downstream streambeds with gravel would occur in the North Santiam, South Santiam, and McKenzie River Basins below Big Cliff, Foster, Cougar, and Blue River Dams. The WVS is restricting sediment transport and subsequently degrading habitat for ESA-listed and other native fish below its dams.

This measure would first involve surveying below the dams to determine where gravel placement could increase usable spawning areas while considering channel bathymetry, water temperature, hydrology, and hydraulics. Then, clean round river gravel would be added to the areas of wetted streambeds that were identified to best improve river substrate conditions for spawning and rearing of native fish species downstream of WVS dams. Gravel would be sized appropriately for use by spawning UWR spring Chinook salmon and UWR winter steelhead, and to the maximum extent feasible, locally sourced. Site-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared for each location prior to implementation of gravel augmentation.

#### *2.4.2.2 Adapt Hatchery Program (#719)*

The overall goal of this measure would be to adjust production of WVS hatcheries for mitigation obligations and conservation needs after demonstrated improvements to fish access to habitat above dams. Congress authorized USACE to mitigate for the construction of the WVS, recognizing that the dams would block habitat access for migratory fish and inundate habitat and existing hatcheries. USACE has historically done this by carrying out a program to produce and release hatchery salmon, steelhead trout, and game fish in the WVB (Figure 2.5-1).

Congress did not define detailed goals for mitigation, including the level of fish production to be achieved. This left USACE discretion to determine how to implement the fish mitigation program in the WVB, whether that be through hatchery programs, passage improvements, or a combination. Current levels of mitigation production are defined in HGMPs prepared by ODFW and USACE as discussed in Section 1.6.2.

If fish passage measures are successful, they would provide access to habitat once blocked by the WVS; so USACE is proposing to reduce the hatchery production amounts needed for mitigation after demonstrated improvement to fish habitat access. Sub-basins where there are

Willamette Hatchery Mitigation Program production goals include the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette. Each sub-basin hatchery program would be considered separately according to the metrics and protocols described in the detailed measure description provided in Appendix A.

**Figure 2.4-1. McKenzie River Fish Hatchery Near Leaburg, Oregon**

#### *2.4.2.3 Maintain Revetments considering Nature-based Engineering or Alter Revetments for Aquatic Ecosystem Restoration (#9)*

As described in Section 1.6.1, the Willamette River Basin Bank Protection Program (WRBBPP) consists of 193 active bank protection structures, 83 of which are maintained by USACE and 105 of which are maintained by a local non-federal sponsor (USACE, 2000). Figure 2.5-2 provides a map of all bank protection structures in the WRBBPP.

Under this measure USACE would continue to implement maintenance of revetments throughout the basin, as funded, to support WRBBPP bank protection structures currently managed by USACE.

Nature-based methods would be included, to the extent the project purpose is maintained, by decreasing hard surfaces (e.g., rock) within the system to provide habitat for various fish and wildlife species in the river margins and riparian zone while maintaining the authorized project purposes.

This measure would be implemented as part of maintenance actions and would include:

- Consideration of nature-based engineering options as part of any USACE maintenance activity for USACE-managed revetments.

- Adherence to standard engineering practices for maintenance such that the revetment would still meet intended authorized purposes.

In addition, USACE would seek opportunities to work with non-federal sponsors to study and work through the process for environmental restoration projects that would substantially alter USACE or non-federally managed WVS revetments. Continuing Authority Program Section 1135, Project Modifications for Improvement of the Environment (WRDA, 1986), is the only authority that allows USACE to alter a federal project for ecosystem restoration purposes.

Under Continuing Authority Program studies, USACE must have a non-federal sponsor to cost share the project, acquire all necessary real estate permissions, and agree to operate and maintain the project in perpetuity. Working with NMFS and USFWS, as well as local agencies and stakeholders, USACE would seek non-federal sponsors for substantial alterations to provide ecological improvements to one or more WRBBPP structures that are determined to be in the federal interest using the Aquatic Ecosystem Restoration metrics (cost per habitat unit).

Project-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared for Continuing Authority Program studies. However, it should be noted the requirement to find a sponsor severely limits the ability for USACE to carry out large scale changes under this program.

Existing information would be used to identify projects with the greatest potential for improving habitat without posing an increased FRM risk; however, additional technical analyses would likely be necessary to further evaluate potential effects of the modifications. Post-construction monitoring would also be conducted to ensure that the project performs as intended, both biologically and for bank protection. This information would also be used to investigate the implementation of future substantial alterations to revetments.

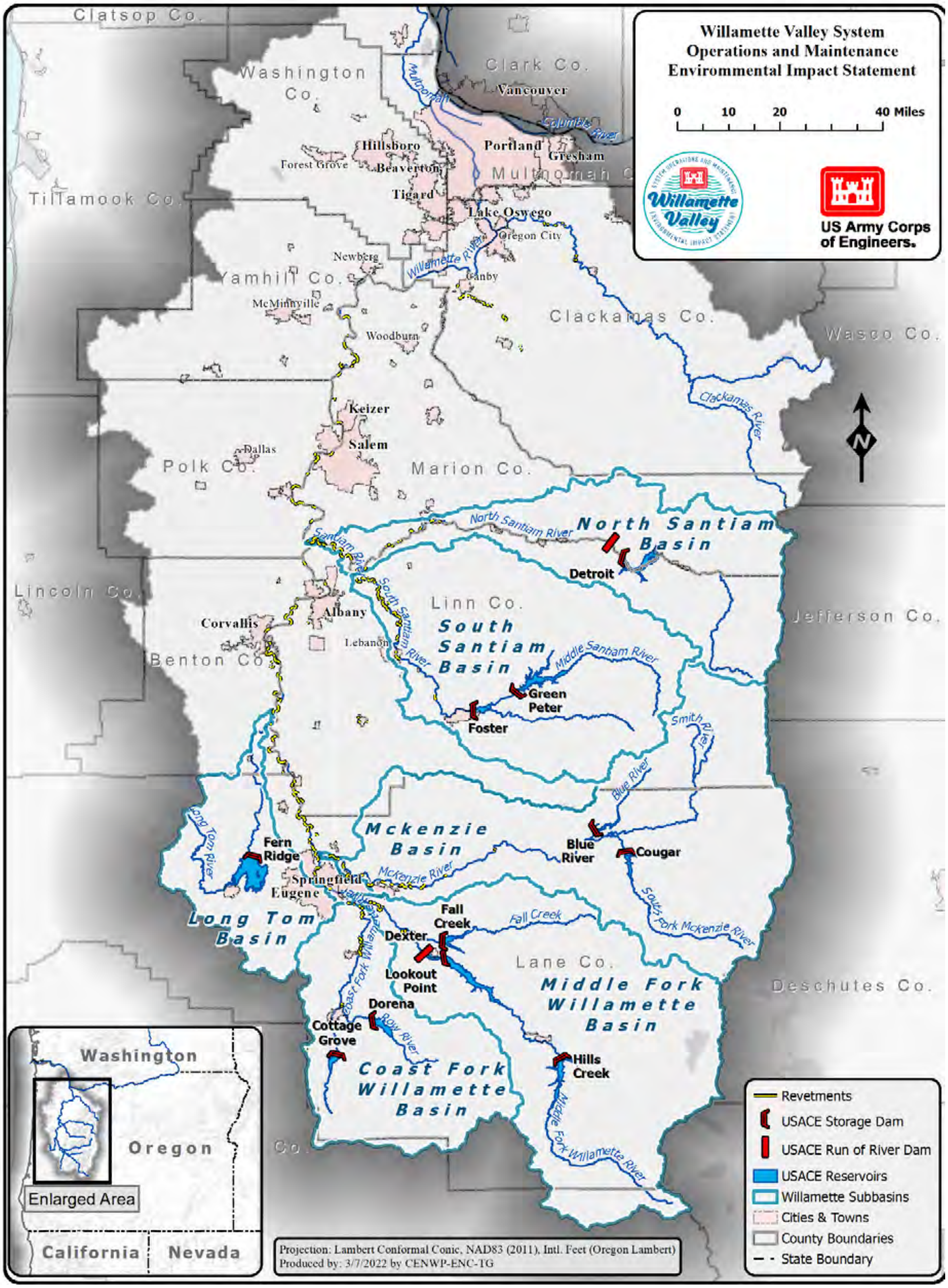


**Figure 2.4-2. Willamette River Basin Bank Protection Program Revetment Locations**

### *2.4.2.4 Maintenance of Existing and New Fish Release Sites above Dams (#726)*

Basin-wide actions would be taken to ensure safe and effective release of outplanted adult fish and to support upstream passage above dams. Outplanting refers to transporting adult UWR spring Chinook salmon and UWR winter steelhead and releasing them in stream reaches above WVS reservoirs.

Specific actions would vary within the WRB by outplant reach, but in general, adult hatchery fish would be outplanted to support salmonid reintroduction with a goal of eventually only outplanting returning adult wild fish to locations upstream of barriers to migration (dams and reservoirs). Several release sites (Table 2.5-6) were evaluated for this measure based on their access to high quality habitat. Some proposed sites may require minor improvements that may require minimal construction. In cases where construction would be required, site-specific designs and environmental compliance (as described in Chapter 7) would be completed, if needed.

**Table 2.4-6. Current and Proposed Outplanting Sites**

| Project | Description | Existing or Proposed |
|---|---|---|
| **Detroit** | Private Site | Proposed |
| | Breitenbush USGS Gage Site (#14179000) | Proposed |
| | Parrish Lake Road (Upper) | Existing |
| | Cooper's Ridge (Lower) | Existing |
| **Minto (Big Cliff)** | North Santiam River upstream of Minto | Existing |
| **Foster** | Gordon Road (Upper) | Existing |
| | River Bend A (Lower) | Existing |
| | Reservoir release | Proposed |
| **Cougar** | Hardrock campground (lower) | Existing |
| | Homestead campground (upper) | Proposed |
| **Lookout Point** | Site 1 (lower) | Existing |
| | Site 3 (upper) | Proposed |
| **Fall Creek** | Gold Creek Confluence (upper) | Existing |
| | Site C (lower) | Existing |
| **Hills Creek** | Construction site (spur road) | Existing |
| | Paddy's Valley | Existing |
| **Blue River** | Lower release site 2-5 miles above head of reservoir | Proposed |
| **Green Peter** | Lower release site 2-5 miles above head of reservoir in Quartzville Creek | Proposed |
| **Green Peter** | Lower release site 2-5 miles above head of reservoir in Middle Santiam | Proposed |

### 2.4.3 Adaptive Management Common to All Action Alternatives

Adaptive management would be applied to any selected action alternative. As described in Section 5.5, an Adaptive Management Plan would be prepared that outlines the governance framework[17] to be used for adaptive decision-making, the annual adaptive management process for engaging with stakeholders, and the process to incorporate new learning into management priorities. The Adaptive Management Plan would also outline the decision criteria relevant to monitoring and evaluating the success of management measures at achieving stated objectives.

### 2.4.4 Existing Operations Common to All Alternatives

This section describes current operations that would continue under all action alternatives.

#### *2.4.4.1 Fall Creek Drawdown*

The annual drawdown at Fall Creek would continue as described under the NAA. Fall Creek Reservoir would continue to be drawn down to its lowest outlet, elevation 690 feet, for a few weeks in November lasting sometime into December. The actual operation would vary based on when the majority of fish are observed to be present and are passing.

#### *2.4.4.2 Continued Operation of Existing Adult Fish Facilities*

USACE would continue to operate and maintain the existing adult fish collection facilities located at Dexter, Foster, Fall Creek, Minto (downstream of Big Cliff), and Cougar Dams (Figure 1.6-2) in accordance with the WFOP, the operational plan noted in Section 1.8.8. The WFOP is developed annually by USACE in coordination with the BPA as well as regional federal, state, Tribal fish agencies, and other partners through the WFPOM coordination team. Generally, adult fish collection facilities are operated annually between April and October.

#### *2.4.4.3 Operation, Maintenance, Repair, Replacement, and Rehabilitation*

USACE would continue to implement the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) program at each WVS facility, consisting of routine inspections and maintenance of both power and non-power assets. USACE utilizes computerized maintenance management systems to plan, schedule, resource, and track this work.

##### *2.4.4.3.1 Scheduled/Routine Maintenance*

Routine maintenance would continue as described in Section 1.8.7.

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[17] A governance framework as part of the Adaptive Management Plan will specifically describe how USACE will continue to work the WATER to design a robust research, monitoring, and evaluation plan to inform decision-making during implementation of the selected alternative.

###### *2.4.4.3.2 Major Maintenance and Rehabilitation*

Major maintenance and rehabilitation would occur as described in Section 1.8.7.

The following describes each of the alternatives analyzed in the PEIS.

### 2.4.5 Alternative 1. Improve Fish Passage Through Storage-focused Measures (Project Storage Alternative)

Under Alternative 1, also referred to as the Project Storage Alternative, USACE would maximize the refill volumes of conservation pools at WVS reservoirs to meet authorized purposes that depend on full reservoirs, including M&I water supply, AI, recreation, and water quality, and improve fish passage through the WVS dams to increase the survival of ESA-listed fish species.

#### *2.4.5.1 Stream Flow*

Flows would be reduced to the Congressionally authorized minimum flows (Measure #723) to benefit reservoir refill objectives at all project locations, as described in Section 2.3.1.5. This would increase the likelihood of refilling the WVS reservoirs to their maximum conservation pool levels in the spring. However, Alternative 1 would also augment instream flows by using the power pool (Measure #304) at Lookout Point, Hills Creek, Cougar, Green Peter and Detroit Dams, and by using the inactive pools at Cottage Grove, Dorena, Fall Creek, and Blue River Dams (Measure #718), as described in Section 2.3.1.2 and Section 2.3.1.4, respectively. These two measures would augment flows for biological purposes at critical times of the year and reduce temperatures.

#### *2.4.5.2 Water Quality*

Under Alternative 1, many structural improvements would also be implemented for water quality purposes as well as for downstream and upstream fish passage. Site-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared for each of these construction measures.

Structural measures for water quality would include structural improvements to reduce TDG (Measure #174) at Dexter, Cougar, and Foster Dams, as described in Section 2.2.2.3. Structural measures in this alternative also include constructing WTC towers (Measure #105 described in Section 2.3.2.1) at Lookout Point, Green Peter, and Detroit dams.

#### *2.4.5.3 Total Dissolved Gas*

The WTC towers at these dams would also be structurally designed to reduce TDG (Measure #174). The WTC towers would be paired with a FSS (Measure #392) to provide downstream passage, as described in Section 2.3.3.4. The towers would have slots that allow the FSS to move up and down with annual reservoir elevation changes. The structures would allow for fish collection over various water levels throughout the year, with the intent of minimizing effects to project storage from operations for fish passage and water quality.

### *2.4.5.4 Fish Passage*

Fish collected at Lookout Point, Green Peter, and Detroit Dams would be transported and released downstream of their reregulation dams (Dexter, Foster, and Big Cliff dams, respectively) so that these fish would not have to find passage over the reregulating dams. At Foster, Alternative 1 includes the Foster Fish Ladder Temperature Improvement (Measure #479 described in Section 2.3.2.4) and modification of the existing surface route structure (fish weir) for improved downstream passage (Measure #392 as described in Section 2.2.3.4).

To address upstream passage needs, an adult fish collection facility would be constructed at the Green Peter Dam (Measure #722 described in Section 2.2.4). Upstream and downstream fish passage would be restored downstream of the Fern Ridge Dam at the Monroe, Stroda, and Cox Butte drop structures (Measure #639 described in Section 2.2.4). The design of the adult fish facility at Green Peter and fish passage restoration at the drop structures below Fern Ridge Dam would include Pacific lamprey passage (Measure #52 described in Section 2.2.4).

All the measures for Alternative 1 and the locations at which they would be implemented are shown in Table 2.5-7.

Note that the following abbreviations for the WVS projects are used in each alternative table:

- FRN – Fern Ridge
- CTG – Cottage Grove
- DOR – Dorena
- DEX – Dexter
- LOP – Lookout Point
- FCR – Fall Creek
- HCR – Hills Creek
- CGR – Cougar
- BLU – Blue River
- FOS – Foster
- GPR – Green Peter
- BCL – Big Cliff
- DET – Detroit

**Table 2.4-7. Alternative 1 Measures and Locations**

| PROJECT/DAM | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Near-term Operational Measure** | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **FLOW MEASURE NUMBER & DESCRIPTION** | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **30a.** Integrated temperature and habitat flow regime | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **30b.** Refined Integrated temperature and habitat flow regime | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **304.** Augment instream flows by using the power pool | – | – | – | – | X | – | X | X | – | – | X | – | X |
| **718.** Augment instream flows by using inactive pool | – | X | X | – | – | X | – | – | X | – | – | – | – |
| **723.** Reduce minimum flows to Congressionally authorized minimum flow requirements | X | X | X | X | X | X | X | X | X | X | X | X | X |
| **WATER QUALITY MEASURE NUMBER AND DESCRIPTION** | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **105.** Construct water temperature control tower | – | – | – | – | X | – | – | – | – | – | X | – | X |
| **166.** Use regulating outlets for temperature management | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **174.** Structural improvements to reduce TDG | – | – | – | X | X[1] | – | – | X | – | X | X[1] | – | X[1] |
| **479.** Foster fish ladder temperature improvement | – | – | – | – | – | – | – | – | – | X | – | – | – |
| **721.** Use spillway for surface spill in summer | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **DOWNSTREAM PASSAGE MEASURE NUMBER AND DESCRIPTION** | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **40.** Deeper fall reservoir drawdowns for downstream fish passage as compared to current conditions | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **392.** Construct structural downstream fish passage | – | – | – | X[2] | X | – | – | – | – | X | X | X[2] | X |
| **714.** Pass water over spillway in spring for downstream fish passage | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 720. Spring reservoir drawdown for downstream fish passage | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **UPSTREAM PASSAGE MEASURE NUMBER AND DESCRIPTION** | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **52.** Provide Pacific lamprey passage and infrastructure | X | – | – | – | – | – | – | – | – | – | X | – | – |

| PROJECT/DAM | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **639.** Restore upstream and downstream passage at drop structures | X | – | – | – | – | – | – | – | – | – | – | – | – |
| **722**. Construct adult fish facility | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **Measures Common to All Alternatives** | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **384.** Gravel augmentation | – | – | – | – | – | – | – | X | X | X | – | X | – |
| **719**. Adapt Hatchery Program | – | – | – | X | X | X | X | X | X | X | X | X | X |
| **9.** Maintain revetments considering nature-based engineering or alter revetments for aquatic ecosystem restoration | X[3] | X[3] | X[3] | X[3] | X[3] | X[3] | X[3] | X[3] | X[3] | X[3] | X[3] | X[3] | X[3] |
| **726**. Maintenance of existing and new fish release sites above dams | – | – | – | – | X | X | X | X | – | X | X | X | X |
| Fall Creek drawdown | – | – | – | – | – | X | – | – | – | – | – | – | – |
| Continued operation of existing Adult Fish Facilities | – | – | – | X | – | X | – | X | – | X | – | X | – |
| Maintenance of WVS facilities | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Adaptive Management | X | X | X | X | X | X | X | X | X | X | X | X | X |

[1]Incorporated into design of 105

[2]Fish will be collected at upstream dam and transported downstream of re-regulation dam

[3] Basin-wide including Willamette River

### 2.4.6 Alternative 2A. Integrated Water Management Flexibility and ESA-listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam) (Hybrid Alternative with Cougar Floating Screen Structure)

Alternative 2A was developed to improve fish passage through the WVS dams using a combination of modified operations and structural improvements, along with other measures to balance water management flexibility and meet ESA-listed fish obligations. Alternative 2A is also referred to as the Hybrid Alternative with Cougar Floating Screen Structure.

Alternative 2A was developed after action Alternatives 1, 3A, 3B, and 4 to allow for very cursory modeling results from these alternatives to inform the formulation of Alternative 2A. Prior to this modeling, it was difficult to know which operational measures under Alternatives 3A or 3B would provide suitable downstream passage results when compared to the structure-focused alternative (Alternative 4).

Structural measures require comprehensive design and engineering efforts, additional environmental compliance (such as site-specific NEPA documents), and often long construction timeframes. These requirements can substantially delay a structural measure's implementation and substantially increase the cost of an alternative. Thus, the formulation of Alternative 2A was an effort to identify the combination of structural and operational downstream fish passage measures that could more effectively meet ESA objectives, while balancing the challenges of large-scale structural changes. Site-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared for each of the measures requiring construction.

#### *2.4.6.1 Near-term Operations Implementation*

Under Alternative 2A, the near-term operations measure (discussed in Section 2.2.5) would be implemented. The near-term operations measure combines operations at different locations, that can be implemented immediately, into a single measure. The operation at a location would be implemented until the structural measure for that location can be constructed.

If there is not a structure or operation to replace the near-term operation, it would cease upon full implementation of all the measures under the alternative (a detailed analysis of how near-term measures would be replaced by the measures under the Preferred Alternative is provided in Chapter 5). Note that this integration of the near-term operations measure is largely the same for Alternatives 2B, 3A, 3B, 4, and 5 and only differences will be highlighted in those sections.

#### *2.4.6.2 Stream Flow*

Under Alternative 2A, the integrated temperature and habitat flow regime (Measure #30a as described in Section 2.3.1.1) would be utilized at all dams in the WVS. However, this alternative would also augment instream flows by using the power pool (Measure #304) at Lookout Point, Hills Creek, Cougar, Green Peter and Detroit dams, and by using the inactive pools at Fall Creek, and Blue River dams (Measure #718), as described in Section 2.3.1.2 and Section 2.3.1.4, respectively. These two measures would augment flows for biological purposes at critical times of the year and reduce temperatures.

Alternative 2A strikes a balance between implementing operational and structural solutions by incorporating operational downstream fish passage measures at Green Peter Dam, including passing water over the spillway in the spring (Measure #714 as described in Section 2.3.3.2) and a deep fall drawdown (Measure #40 as described in Section 2.3.3.1) with the construction of downstream fish passage structures at Detroit, Lookout Point, Cougar, and Foster Dams as described below in Section 2.4.4.4.

#### *2.4.6.3 Adult Fish Facility and Fish Passage*

Alternative 2A would also include a new adult fish facility for upstream fish passage at Green Peter (Measure #722 as described in Section 2.2.4) that would provide passage for Pacific lamprey (Measure #52 described in Section 2.2.4). Structural downstream passage (Measure #392) is proposed at Lookout Point, Cougar, and Detroit Dams as described in Section 2.2.3.4.1, and at Foster Dam as described in Section 2.2.3.4.2. Fish collected at Lookout Point and Detroit dams would be transported and released downstream of their reregulation dams (Dexter and

Big Cliff dams, respectively) so that these fish would not have to find passage over the reregulating dams.

### *2.4.6.4 Water Quality*

Alternative 2A would also include a combination of structural and operational measures to address water quality. The fish passage structure at Detroit would be integrated with a WTC tower (Measure #105 as described in Section 2.3.2.1). However, a WTC tower at Hills Creek was omitted from this alternative after initial modeling showed an inability to affect temperatures downstream of Dexter Dam.

For temperature control at Green Peter Dam, Alternative 2A would include the following operational measures:

- Using the ROs to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below these dams (Measure #166 as described in Section 2.3.2.2) and;
- Using the spillway for surface spill in summer (Measure #721 as described in Section 2.3.2.5).

At Foster Dam, Alternative 2A would include the Foster fish ladder temperature improvement (Measure #479 described in Section 2.2.2.4) and modification of the existing surface route structure (fish weir) for improved downstream passage (Measure #392 as described in Section 2.2.3.4.1).

All the measures for Alternative 2A and the locations at which they would be implemented are shown in Table 2.5-8.

**Table 2.4-8. Alternative 2A Measures and Locations**

| PROJECT/DAM | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Near-term Operational Measure | – | – | – | – | X | X | X | X | – | X | X | X | X |
| **FLOW MEASURE NUMBER AND DESCRIPTION** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **30a**. Integrated temperature and habitat flow regime | X | X | X | X | X | X | X | X | X | X | X | X | X |
| **30b**. Refined Integrated temperature and habitat flow regime | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **304.** Augment instream flows by using the power pool | – | – | – | – | X | – | X | X | – | – | X | – | X |
| **718.** Augment instream flows by using inactive pool | – | – | – | – | – | X | – | – | X | – | – | – | – |

| PROJECT/DAM | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **723.** Reduce minimum flows to Congressionally authorized minimum flow requirements | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **WATER QUALITY MEASURE NUMBER AND DESCRIPTION** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **105.** Construct water temperature control tower | – | – | – | – | – | – | – | – | – | – | – | – | X |
| **166.** Use regulating outlets for temperature management | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **174**. Structural improvements to reduce TDG | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **479.** Foster fish ladder temperature improvement | – | – | – | – | – | – | – | – | – | X | – | – | – |
| **721**. Use spillway for surface spill in summer | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **DOWNSTREAM PASSAGE MEASURE NUMBER AND DESCRIPTION** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **40.** Deeper fall reservoir drawdowns for downstream fish passage than under current conditions | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **392**. Construct structural downstream fish passage | – | – | – | [1] | X | – | – | X | – | X | – | [1] | X |
| **714.** Pass water over spillway in spring for downstream fish passage | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **720.** Spring reservoir drawdown for downstream fish passage | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **UPSTREAM PASSAGE MEASURE NUMBER AND DESCRIPTION** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **52.** Provide Pacific lamprey passage and infrastructure | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **639.** Restore upstream and downstream passage at drop structures | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **722.** Construct adult fish facility | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **Measures Common to All Alternatives** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **384.** Gravel augmentation | – | – | – | – | – | – | – | X | X | X | – | X | – |
| **719**. Adapt Hatchery Program | – | – | – | X | X | X | X | X | X | X | X | X | X |

| PROJECT/DAM | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **9.** Maintain revetments considering nature-based engineering or alter revetments for aquatic ecosystem restoration | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] |
| **726**. Maintenance of existing and new fish release sites above dams | – | – | – | – | X | X | X | X | – | X | X | X | X |
| Fall Creek drawdown | – | – | – | – | – | X | – | – | – | – | – | – | – |
| Continued operation of existing Adult Fish Facilities | – | – | – | X | – | X | – | X | – | X | – | X | – |
| Maintenance of WVS facilities | X | X | X | X | X | x | X | x | X | X | X | X | X |
| Adaptive Management | X | X | X | X | X | X | X | X | X | X | X | X | X |

[1]Fish will be collected at upstream dam and transported downstream of re-regulation dam

[2]Basin-wide including Willamette River

### 2.4.7 Alternative 2B. Integrated Water Management Flexibility and ESA-listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel) (Hybrid Alternative with Cougar Diversion Tunnel Modification)

Actions and measures under Alternative 2B would be the same as under Alternative 2A but would include a modification to the combination of measures at Cougar Dam. Alternative 2B is also referred to as the Hybrid Alternative with Cougar Diversion Tunnel Modification. Only the differences between Alternative 2B and Alternative 2A are discussed below.

Measures under Alternative 2B and Alternative 2A would be identical except for the downstream passage measure via the DT at Cougar Dam as described in Section 2.2.3.1. The use of structural versus operational downstream passage measures has unique environmental and operational implications. By identifying the distinction between Alternative 2A (i.e., structural measure) and Alternative 2B (i.e., operational measure), the unique impacts associated with a structure versus an operation are disclosed. Specifically, this distinction is demonstrated for downstream passage at Cougar Dam. The environmental consequences between structural (Alternative 2A) and operational measures (Alternative 2B) at Cougar Dam are then assessed and compared in Chapter 3.

Specifically, structural downstream fish passage would be constructed at Cougar Dam under Alternative 2A (Measure #392 as described in Section 2.2.3.4). In contrast, under Alternative 2B operations would be changed at Cougar Dam by drafting the reservoir down within 25 feet of the DT, located at the bottom of the reservoir (Figure 2.3-9) so that fish can pass through the DT in the fall and spring (Measures #40 and #720 as described in Sections 2.3.3.1 and 2.3.3.3, respectively). A drawdown to the DT at Cougar Dam would require several dam modifications to make this operation possible and a change in operational authority.

First, dam safety concerns associated with Cougar Reservoir's fluctuating pool levels would need to be addressed. Second, redundant gate structures to allow for safe, remote, routine operation of the DT would need to be designed and constructed. Finally, the DT would need to be made accessible for O&M through the construction of a tower and bridge. Site-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared for these required modifications.

Under Alternative 2B, fall and spring deep drawdowns to the DT for fish passage would draft the reservoir below the power pool most of the time, making the power pool inaccessible for flow augmentation (Measure #40 and Measure #720 as described in Section 2.2.3.1 and Section 2.3.3.3, respectively) (Measure #304, Section 2.2.1). Alternative 2B As discussed in Section 2.3.3.1, modifications to the Cougar DT needed to perform this operation would require site-specific construction and environmental compliance (as described in Chapter 7).

The measures for this alternative and the locations at which they would be implemented are shown in Table 2.5-9. Site-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared for each of the measures requiring construction.

**Table 2.4-9. Alternative 2B Measures and Locations**

| PROJECT/DAM | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Near-term Operational Measure** | – | – | – | – | X | X | X | X | – | X | X | X | X |
| **FLOW MEASURE NUMBER AND DESCRIPTION** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **30a.** Integrated temperature and habitat flow regime | X | X | X | X | X | X | X | X | X | X | X | X | X |
| **30b.** Refined Integrated temperature and habitat flow regime | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **304.** Augment instream flows by using the power pool | – | – | – | – | X | – | X | – | – | – | X | – | X |
| **718.** Augment instream flows by using inactive pool | – | – | – | – | – | X | – | – | X | – | – | – | – |
| **723.** Reduce minimum flows to Congressionally authorized minimum flow requirements | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **WATER QUALITY MEASURE NUMBER AND DESCRIPTION** | | | | | | | | | | | | | |
| **105.** Construct water temperature control tower | – | – | – | – | – | – | – | – | – | – | – | – | X |
| **166.** Use regulating outlets for temperature management | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **174.** Structural improvements to reduce TDG | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **479.** Foster fish ladder temperature improvement | – | – | – | – | – | – | – | – | – | X | – | – | – |

| PROJECT/DAM | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **721.** Use spillway for surface spill in summer | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **DOWNSTREAM PASSAGE MEASURE NUMBER AND DESCRIPTION** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **40.** Deeper fall reservoir drawdowns for downstream fish passage than under current conditions | – | – | – | – | – | – | – | X[1] | – | – | X | – | – |
| **392.** Construct structural downstream fish passage | – | – | – | – | X | – | – | – | – | X | – | – | X |
| **714.** Pass water over spillway in spring for downstream fish passage | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **720.** Spring reservoir drawdown for downstream fish passage | – | – | – | – | – | – | – | X[1] | – | – | – | – | – |
| **UPSTREAM PASSAGE MEASURE NUMBER AND DESCRIPTION** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **52.** Provide Pacific lamprey passage and infrastructure | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **639.** Restore upstream and downstream passage at drop structures | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **722.** Construct adult fish facility | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **Measures Common to All Alternatives** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **384.** Gravel augmentation | – | – | – | – | – | – | – | X | X | X | – | X | – |
| **719.** Adapt Hatchery Program | – | – | – | X | X | X | X | X | X | X | X | X | X |
| **9.** Maintain revetments considering nature-based engineering or alter revetments for aquatic ecosystem restoration | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] |
| **726.** Maintenance of existing and new fish release sites above dams | – | – | – | – | X | X | X | X | – | X | X | X | X |
| Fall Creek drawdown | – | – | – | – | – | X | – | – | – | – | – | – | – |
| Continued operation of existing Adult Fish Facilities | – | – | – | X | – | X | – | X | – | X | – | X | – |
| Maintenance of WVS facilities | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Adaptive Management | X | X | X | X | X | X | X | X | X | X | X | X | X |

[1] Draw down to DT. Requires structural modification to the DT

[2] Basin-wide including Willamette River

## 2.4.8 Alternative 3A. Improve Fish Passage Through Operations-focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet) (Operations-focused Fish Passage Alternative)

Alternative 3A was developed to improve fish passage through the WVS dams by modifying operations rather than focusing on storage (as under Alternative 1) or structural measures (as under Alternative 4). Alternative 3A is also referred to as the Operations-focused Fish Passage Alternative.

This alternative includes operational measures that allow for increased survival of ESA-listed fish while maintaining the USACE FRM mission. Operational measures under Alternative 3A are intended to improve downstream fish passage, increase water management flexibility, optimize conservation season draft rates, and reduce impaired water quality below the WVS dams to benefit ESA-listed fish species. Some operational measures may require the modification of existing infrastructure, or the construction of adult fish collection facilities for benefits to be realized from the proposed operational measures.

Under Alternative 3A, as under Alternative 2A and Alternative 2B, the near-term operations measure would be implemented (Section 2.2.5 and Section 2.2.6). The operations in the near-term operations measure would be replaced immediately at the locations where the long-term operation in Alternative 3a is proposed.

### *2.4.8.1 Stream Flow*

Under Alternative 3A, the integrated temperature and habitat flow regime (Measure #30a, Section 2.3.1.1) would be applied the same as under Alternative 2A and Alternative 2B. Instream flows would also be augmented by using the power pool (Measure #304, Section 2.2.1), but would utilize the inactive pools at additional dams: Cottage Grove, Dorena, Fall Creek, and Blue River Dams. These measures would augment flows for biological purposes at critical times of the year and would reduce temperatures.

### *2.4.8.2 Water Quality*

Under Alternative 3A, ROs would be used to discharge colder water during drawdown operations in fall and winter to reduce water temperatures (Measure #166, Section 2.3.2.2) below Lookout Point, Green Peter, and Detroit dams. Also at these dams, and at Hills Creek, Blue River, and Foster Dams, the spillways would be used for surface spill in summer (Measure #721, Section 2.3.2.5). The spillways at Hills Creek and Blue River Dams and the fish weir at Foster Dam would be modified for this measure, requiring site-specific construction and environmental compliance (as described in Chapter 7), which would be prepared for each of the measures requiring construction.

### *2.4.8.3 Adult Fish Facility and Fish Passage*

Alternative 3A proposes new adult fish facilities for upstream fish passage (Measure #722, Section 2.2.4) at Hills Creek, Blue River, and Green Peter Dams. These facilities would also provide Pacific lamprey passage and infrastructure (Measure #52, Section 2.2.4). Additional upstream fish passage would be provided by means of existing trap and haul facilities.

No structural downstream fish passage measures are included under Alternative 3A. Operations-based fish passage measures include:

- Deeper fall season reservoir drawdowns at Lookout Point, Hills Creek, Green Peter, Detroit, Blue River, and Cougar (to the RO) dams (Measure #40, Section 2.2.3.1) as compared to the NAA.
- Spring drawdowns (Measure #720, Section 2.3.3.3) at Lookout Point, Detroit, and Cougar (to the RO) dams.
- The use of spillways (Measure #714, Section 2.3.3.2) to facilitate downstream fish passage at Dexter, Fall Creek, Hills Creek, Green Peter, and Big Cliff dams.

The measures for Alternative 3A and the locations at which they would be implemented are shown in Table 2.5-10.

**Table 2.4-10. Alternative 3A Measures and Locations**

| PROJECT/DAM | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Near-term Operational Measure** | – | – | – | – | X | X | X | X | – | X | X | X | X |
| **FLOW MEASURE NUMBER AND DESCRIPTION** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **30a.** Integrated temperature and habitat flow regime | X | X | X | X | X | X | X | X | X | X | X | X | X |
| **30b.** Refined Integrated temperature and habitat flow regime | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **304.** Augment instream flows by using the power pool | – | – | – | – | X | – | X | X | – | – | X | – | X |
| **718.** Augment instream flows by using inactive pool | – | X | X | – | – | X | – | – | X | – | – | – | – |
| **723.** Reduce minimum flows to Congressionally authorized minimum flow requirements | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **WATER QUALITY MEASURE NUMBER AND DESCRIPTION** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **105.** Construct water temperature control tower | – | – | – | – | – | – | – | – | – | – | – | – | – |

| PROJECT/DAM | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **166**. Use regulating outlets for temperature management | – | – | – | – | X | – | – | – | – | – | X | – | – |
| **174.** Structural improvements to reduce TDG | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **479**. Foster fish ladder temperature improvement | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **721**. Use spillway for surface spill in summer | – | – | – | – | X | – | X[2] | – | X[2] | X[2] | X | – | X |
| **40.** Deeper fall reservoir drawdowns for downstream fish passage than under current conditions | – | – | – | - | X | – | X | X[3] | X | – | X | – | X |
| **392**. Construct structural downstream fish passage | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **714**. Pass water over spillway in spring for downstream fish passage | – | – | – | X | – | X | X | – | – | – | X | X | – |
| **720**. Spring reservoir drawdown for downstream fish passage | – | – | – | – | X | – | – | X[3] | – | – | – | – | X |
| **52**. Provide Pacific lamprey passage and infrastructure | – | – | – | – | – | – | X | – | X | – | X | – | – |
| **639.** Restore upstream and downstream passage at drop structures | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **722**. Construct adult fish facility | – | – | – | – | – | – | X | – | X | – | X | – | – |
| **Measures Common to All Alternatives** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **384.** Gravel augmentation | – | – | – | – | – | – | – | X | X | X | – | X | – |
| **719**. Adapt Hatchery Program | – | – | – | X | X | X | X | X | X | X | X | X | X |
| **9.** Maintain revetments considering nature-based engineering or alter revetments for aquatic ecosystem restoration | X[4] | X[4] | X[4] | X[4] | X[4] | X[4] | X[4] | X[4] | X[4] | X[4] | X[4] | X[4] | X[4] |
| **726.** Maintenance of existing and new fish release sites above dams | – | – | – | – | X | X | X | X | – | X | X | X | X |
| Fall Creek drawdown | – | – | – | – | – | X | – | – | – | – | – | – | – |
| Continued operation of existing Adult Fish Facilities | – | – | – | X | – | X | – | X | – | X | – | X | – |
| Maintenance of WVS facilities | X | X | X | X | X | x | X | x | X | X | X | X | X |
| Adaptive Management | X | X | X | X | X | X | X | X | X | X | X | X | X |

[1]Requires structural modification to the RO

[2]Requires structural modification to the spillway

[3]Drawdown to the RO

[4]Basin-wide including Willamette River

### 2.4.9 Alternative 3B. Improve Fish Passage Through Operations-focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel) (Operations-Focused Fish Passage Alternative)

Actions and measures under Alternative 3B would be the same as under Alternative 3A but would include a modification to the combination of operational measures for downstream fish passage. The description for Alternative 3B addresses only the distinction with Alternative 3A.

Measures under Alternative 3B and Alternative 3A would be identical except for operational measures for downstream fish passage. Variations in operational measures result in unique environmental and operational implications. By identifying the downstream fish passage operational distinctions between Alternative 3A and Alternative 3B, the unique impacts associated with downstream fish passage operational differences are disclosed. The environmental consequences between downstream fish passage measures under Alternative 3A and operational measures under Alternative 3B are then assessed and compared in Chapter 3.

Specifically, Alternative 3A includes downstream fish passage elements at a different combination of projects than under Alternative 3B. Alternative 3A also includes drawdown drafting to 10 feet over the top of the Cougar Dam RO for deep fall and spring drawdown measures. Conversely, Alternative 3B includes drawdown drafting to the DT at Cougar Dam for both drawdown measures, a much deeper drawdown than proposed under Alternative 3A.

As under Alternative 3A, Alternative 3B includes the two measures that augment flows for biological purposes at critical times of the year and to reduce temperatures. Instream flows would be augmented under both Alternative 3A and Alternative 3B by using the inactive pools at Cottage Grove, Dorena, Fall Creek, and Blue River dams (Measure #718, Section 2.3.1.4). However, under Alternative 3B, instream flows would only be augmented by using the power pool (Measure #304, Section 2.2.1) at Lookout Point, Hills Creek, Green Peter, and Detroit dams (Section 2.3.1.2).

Unlike Alternative 3A, Alternative 3B includes the deep fall and spring drawdowns to the DT for downstream fish passage (Measure #40, Section 2.2.3.1 and Measure #720, Section 2.3.3.3) that would draft the reservoir below the power pool most of the time and result in the power pool becoming inaccessible for flow augmentation (Measure #304, Section 2.2.1). As discussed in Section 2.3.3.1, needed modifications to the Cougar DT to perform this operation would require site-specific construction and environmental compliance (as described in Chapter 7).

The other downstream passage measures proposed under Alternative 3B include:

- Deeper fall season reservoir drawdowns than under current conditions identical to Alternative 3A.
- Spring drawdowns at Hills Creek and Green Peter dams (as compared to spring drawdowns at Lookout Point and Detroit dams under Alternative 3A) (Measure #720, Section 2.3.3.3).

- The use of spillways to facilitate downstream fish passage at four dams: Dexter, Lookout Point, Big Cliff, and Detroit Dams (Measure #714, Section 2.3.3.2). This differs from Alternative 3A where spillway use would occur at five dams: Dexter, Big Cliff, Fall Creek, Hills Creek, and Green Peter Dams.

The measures for this alternative and the locations at which they would be implemented are shown in Table 2.4-11.

**Table 2.4-11. Alternative 3B Measures and Locations**

| PROJECT/DAM | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Near-term Operations Measure** | – | – | – | – | X | X | X | X | – | X | X | X | X |
| **FLOW MEASURES** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **30a**. Integrated temperature and habitat flow regime | X | X | X | X | X | X | X | X | X | X | X | X | X |
| **30b.** Refined Integrated temperature and habitat flow regime | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **304.** Augment instream flows by using the power pool | – | – | – | – | X | – | X | – | – | – | X | – | X |
| **718.** Augment instream flows by using inactive pool | – | X | X | – | – | X | – | – | X | – | – | – | – |
| **723.** Reduce minimum flows to Congressionally authorized minimum flow requirements | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **WATER QUALITY MEASURE NUMBERS AND DESRIPTIONS** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **105.** Construct water temperature control tower | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **166.** Use regulating outlets for temperature management | – | – | – | – | X | – | – | – | – | – | X | – | 1 |

| PROJECT/DAM | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **174.** Structural improvements to reduce TDG | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **479.** Foster fish ladder temperature improvement | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **721.** Use spillway for surface spill in summer | – | – | – | – | X | – | X2 | – | X2 | X | X | – | X |
| **DOWNSTREAM PASSAGE MEASURE NUMBER AND DESCRIPTIONS** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **40.** Deeper fall reservoir drawdowns for downstream fish passage than under current conditions | – | – | – | – | X | – | X | X3 | X | – | X | – | X |
| **392.** Construct structural downstream fish passage | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **714.** Pass water over spillway in spring for downstream fish passage | – | – | – | X | X | – | – | – | – | – | – | X | X |
| **720.** Spring reservoir drawdown for downstream fish passage | – | – | – | – | – | – | X | X3 | – | – | X | – | – |
| **UPSTREAM PASSAGE MEASURE NUMBER AND DESCRIPTIONS** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **52.** Provide Pacific lamprey passage and infrastructure | – | – | – | – | – | – | X | – | X | – | X | – | – |
| **639.** Restore upstream and downstream passage at drop structures | – | – | – | – | – | – | – | – | – | – | – | – | – |

| PROJECT/DAM | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **722.** Construct adult fish facility | – | – | – | – | – | – | X | – | X | – | X | – | – |
| **Measures Common to All Alternatives** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **384.** Gravel augmentation | – | – | – | – | – | – | – | X | X | X | – | X | – |
| **719.** Adapt Hatchery Program | – | – | – | X | X | X | X | X | X | X | X | X | X |
| **9.** Maintain revetments considering nature-based engineering or alter revetments for aquatic ecosystem restoration | X4 | X4 | X4 | X4 | X4 | X4 | X4 | X4 | X4 | X4 | X4 | X4 | X4 |
| **726.** Maintenance of existing and new fish release sites above dams | – | – | – | – | X | X | X | X | – | X | X | X | X |
| Fall Creek drawdown | – | – | – | – | – | X | – | – | – | – | – | – | - |
| Continued operation of existing Adult Fish Facilities | – | – | – | X | – | X | – | X | – | X | – | X | – |
| Maintenance of WVS facilities | X | X | X | X | X | x | X | x | X | X | X | X | X |
| Adaptive Management | X | X | X | X | X | X | X | X | X | X | X | X | X |

[1]Requires structural modification to RO.

[2]Requires structural modification to spillway

[3]Drawdown to Cougar DT. Requires structural modification to DT

[4]Basin-wide including Willamette River

### 2.4.10 Alternative 4. Improve Fish Passage with Structures-based Approach (Structures-based Fish Passage Alternative)

Alternative 4 is a structures-based approach to improve fish passage through the WVS dams to increase the survival of ESA-listed fish. It also contains operational measures, such as adjusting conservation season draft rates. Alternative 4 is also referred to as the Structures-based Fish Passage Alternative.

#### *2.4.10.1 Near-term Operations Measure*

Under Alternative 4, as under Alternatives 2A, 2B, 3A, and 3B, the near-term operations measure would be implemented (Section 2.2.5 and Section 2.2.6).

#### *2.4.10.2 Stream Flow*

Under Alternative 4, the integrated temperature and habitat flow regime (Measure #30a, Section 2.3.1.1) would be utilized at all dams in the WVS. However, Alternative 4 would also augment instream flows by using the power pool (Measure #304, Section 2.2.1) at Lookout Point, Hills Creek, Cougar, Green Peter and Detroit dams, and by using the inactive pools at Cottage Grove, Dorena, Fall Creek, and Blue River dams (Measure #718, Section 2.3.1.4). These two measures would augment flows for biological purposes at critical times of the year and reduce temperatures.

#### *2.4.10.3 Water Quality*

Under Alternative 4, structural improvements would also be implemented for water quality purposes as well as for downstream and upstream passage. Site-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared for each of these construction measures.

Structural measures for water quality include structural improvements to reduce TDG at Dexter, Cougar, Foster, and Green Peter dams (Measure #174, Section 2.2.2.3). Structural measures also include constructing WTC towers at Lookout Point, Hills Creek, and Detroit dams (Measure #105, Section 2.3.2.1). The WTC towers at Lookout Point and Detroit dams would also be designed to reduce TDG (Measure #174, Section 2.2.2.3).

#### *2.4.10.4 Adult Fish Facility and Fish Passage*

To address upstream passage needs, an adult fish collection facility would be constructed at Hills Creek Dam (Measure #722, Section 2.2.4). Upstream and downstream fish passage would be restored downstream of the Fern Ridge Dam at the Monroe, Stroda, and Cox Butte drop structures (Measure #639, Section 2.2.4.). The design of the adult fish facility at Hills Creek and fish passage restoration at the drop structures below Fern Ridge Dam would include Pacific lamprey passage (Measure #52, Section 2.2.4).

All three WTC towers would be paired with a FSS attached to provide downstream passage (Measure #392, Section 2.3.3.4). The structures would allow for fish collection over various water levels throughout the year, with the intent of minimizing effects to project storage from operations for fish passage and water quality.

Fish collected at Lookout Point and Detroit dams would be transported and released downstream of their reregulation dams (Dexter and Big Cliff dams, respectively) so that these fish would not have to find passage over the reregulating dams. Alternative 4 includes the construction of a FSS at Cougar Dam attached to the existing WTC tower.

At Foster, Alternative 4 includes Foster fish ladder temperature improvement (Measure #479, Section 2.2.2.4) and modification of the existing surface route structure (fish weir) for improved downstream passage (Measure #392, Section 2.2.3.4).

The measures for this alternative and the locations at which they would be implemented are shown in Table 2.4-12.

**Table 2.4-12. Alternative 4 Measures and Locations**

| PROJECT/DAM | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Near-term Operations Measure** | – | – | – | – | X | X | X | X | – | X | X | X | X |
| **FLOW MEASURE NUMBER AND DESCRIPTION** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **30a**. Integrated temperature and habitat flow regime | X | X | X | X | X | X | X | X | X | X | X | X | X |
| **30b**. Refined Integrated temperature and habitat flow regime | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **304**. Augment instream flows by using the power pool | – | – | – | – | X | – | X | X | – | – | X | – | X |
| **718**. Augment instream flows by using inactive pool | – | X | X | – | – | X | – | – | X | – | – | – | – |
| **723**. Reduce minimum flows to Congressionally authorized minimum flow requirements | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **WATER QUALITY MEASURE NUMBER AND DESCRIPTION** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **105.** Construct water temperature control tower | – | – | – | – | X | – | X | – | – | – | – | – | X |
| **166**. Use regulating outlets for temperature management | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **174.** Structural improvements to reduce TDG | – | – | – | X | X[1] | – | – | X | – | X | X | – | X[1] |
| **479**. Foster fish ladder temperature improvement | – | – | – | – | – | – | – | – | – | X | – | – | – |
| **721.** Use spillway for surface spill in summer | – | – | – | – | – | – | – | – | - | – | X | – | – |
| **DOWNSTREAM PASSAGE MEASURE NUMBER AND DESCRIPTION** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **40.** Deeper fall reservoir drawdowns for downstream fish passage | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **392.** Construct structural downstream fish passage | – | – | – | X[2] | X | – | X | X | – | X | – | X[2] | X |
| **714.** Pass water over spillway in spring for downstream fish passage | – | – | – | – | – | – | – | – | – | – | – | – | – |

| PROJECT/DAM | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **720.** Spring reservoir drawdown for downstream fish passage | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **UPSTREAM PASSAGE MEASURE NUMBER AND DESCRIPTION** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **52.** Provide Pacific lamprey passage and infrastructure | X | – | – | – | – | – | X | – | – | – | – | – | – |
| **639.** Restore upstream and downstream passage at drop structures | X | – | – | – | – | – | – | – | – | – | – | – | – |
| **670.** Update Dexter Adult Fish Facility** specs and handling practices that do not increase the risk of PSM and cease using CO2 | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **722**. Construct Adult Fish Facility | – | – | – | – | – | – | X | – | – | – | – | – | – |
| **Measures Common to All Alternatives** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **384.** Gravel augmentation | – | – | – | – | – | – | – | X | X | X | – | X | – |
| **719.** Adapt Hatchery Program | – | – | – | X | X | X | X | X | X | X | X | X | X |
| **9.** Maintain revetments considering nature-based engineering or alter revetments for aquatic ecosystem restoration | X[3] | X[3] | X[3] | X[3] | X[3] | X[3] | X[3] | X[3] | X[3] | X[3] | X[3] | X[3] | X[3] |
| **726**. Maintenance of existing and new fish release sites above dams | – | – | – | – | X | X | X | X | – | X | X | X | X |
| Fall Creek drawdown | – | – | – | – | – | X | – | – | – | – | – | – | – |
| Continued operation of existing Adult Fish Facilities | – | – | – | X | – | X | – | X | – | X | – | X | – |
| Maintenance of WVS facilities | X | X | X | X | X | x | X | x | X | X | X | X | X |
| Adaptive Management | X | X | X | X | X | X | X | X | X | X | X | X | X |

[1]Incorporated into design of 105

[2]Fish will be collected at upstream dam and transported downstream of re-regulation dam

[3]Basin-wide including Willamette River

### 2.4.11 Alternative 5. Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-listed Fish Alternative (Refined Hybrid Alternative - Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)

Alternative 5 is the USACE Preferred Alternative. This alternative is also called the Refined Hybrid Alternative with Cougar Diversion Tunnel Modification because it is the same as Alternative 2B except that the integrated temperature and habitat flow regime (Measure #30a, Section 2.3.1.1) has been replaced by the refined integrated temperature and habitat flow regime (Measure #30b, Section 2.3.1.2, and Appendix A).

The Preferred Alternative was developed to improve fish passage through the WVS dams using a combination of modified operations and structural improvements, along with other measures to balance water management flexibility and meet ESA-listed fish obligations (Chapter 5).

The Preferred Alternative was developed after the formulation and analyses of all other action alternatives. Alternative 2B was initially proposed as the Preferred Alternative. However, after engaging with BPA, NMFS, and USFWS, USACE determined that the integrated temperature and habitat flow regime proposed under Alternative 2B should be refined to improve outcomes for ESA species (Measure #30a, Section 2.3.1.1).

Consequently, the Preferred Alternative, Alternative 5, is the same as Alternative 2B except that the integrated temperature and habitat flow regime (Measure #30a, Section 2.3.1.1) has been replaced by the refined integrated temperature and habitat flow regime (Measure #30b, Section 2.3.1.2 and Appendix A). Because of this development history, comparisons with Alternative 2B are provided rather than highlighting only differences between the two alternatives.

As with all the action alternatives, site-specific design and environmental compliance documentation (as described in Chapter 7) would be prepared for each of the measures requiring construction.

#### *2.4.11.1 Near-term Operations Measure*

Under the Preferred Alternative, as under Alternatives 2A, 2B, 3A, 3B, and 4, the near-term operations measure would be implemented (Section 2.2.5 and Section 2.2.6). Chapter 5 and Appendix N provides a more detailed analysis of how near-term measures would be replaced by the measures under this alternative.

#### *2.4.11.2 Stream Flow*

Unique to the Preferred Alternative, the refined integrated temperature and habitat flow regime (Measure #30b, Section 2.3.1.2 ) would be utilized at all dams in the WVS. Identical to Alternative 2B, the Preferred Alternative would augment instream flows using the power pool (Measure #304, Section 2.2.1.3) at Lookout Point, Hills Creek, Green Peter and Detroit dams, and by using the inactive pools at Fall Creek, and Blue River dams (Measure #718, Section 2.2.1.4). These two measures would augment flows for biological purposes at critical times of the year and reduce temperatures.

#### *2.4.11.3 Water Quality*

As under Alternative 2B, the Preferred Alternative includes a combination of structural and operational measures to address water quality. The fish passage structure at Detroit Dam would be integrated with a WTC tower (Measure #105, Section 2.3.2.1). A WTC tower at Hills Creek Dam was omitted from this alternative after initial modeling showed an inability to affect temperatures downstream of Dexter Dam.

For temperature control at Green Peter Dam, the Preferred Alternative proposes the following operational measures, which would be the same as Alternative 2B:

- Using the ROs to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below these dams (Measure #166, Section 2.3.2.2).
- Using the spillway for surface spill in summer (Measure #721, Section 2.3.2.5).

Identically to Alternative 2B, the Preferred Alternative includes the Foster fish ladder temperature improvement (Measure #479 described in Section 2.2.2.4) and modification of the existing surface route structure (fish weir) for improved downstream passage (Measure #392 as described in Section 2.2.3.4.2).

Operations at Cougar Dam would be changed by drafting the reservoir down so that fish can pass through the DT in the fall and spring, as under Alternative 2B (Measures #40, Section 2.2.3.1 and #720, Section 2.3.3.3). These deep fall and spring drawdowns to the DT for fish passage would draft the reservoir below the power pool most of the time, making the power pool inaccessible for flow augmentation under the Preferred Alternative (Measure #304, Section 2.2.1.3). As discussed in Section 2.3.3.1, modifications to the Cougar DT needed to perform this operation would require site-specific construction and environmental compliance (as described in Chapter 7).

#### *2.4.11.4 Adult Fish Facility and Fish Passage*

The Preferred Alternative includes a new adult fish facility for upstream fish passage at Green Peter (Measure #722, Section 2.2.4) that would provide passage for Pacific lamprey (Measure #52, Section 2.2.4). As under Alternative 2A and Alternative 2B, the Preferred Alternative includes operational downstream fish passage measures at Green Peter Dam, including passing water over the spillway in the spring (Measure #714, Section 2.3.3.2) and a deep fall drawdown (Measure #40, Section 2.3.3.1). Structural downstream passage measures (Measure #392, Section 2.2.3.4) were proposed only at Lookout Point and Detroit Dams (Section 2.2.3.4.1) and at Foster Dam (Section 2.2.3.4.2).

The measures for the Preferred Alternative and the locations at which they would be implemented are shown in Table 2.5-13.

**Table 2.4-13. Alternative 5, Preferred Alternative, Measures and Locations**

| PROJECT/DAM | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Near-term Operations Measure** | – | – | – | – | X | X | X | X | – | X | X | X | X |
| **FLOW MEASURE NUMBER AND DESCRIPTION** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **30a.** Integrated temperature and habitat flow regime | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **30b.** Refined Integrated temperature and habitat flow regime | X | X | X | X | X | X | X | X | X | X | X | X | X |
| **304.** Augment instream flows by using the power pool | – | – | – | – | X | – | X | – | – | – | X | – | X |
| **718**. Augment instream flows by using inactive pool | – | – | – | – | – | X | – | – | X | – | – | – | – |
| **723**. Reduce minimum flows to Congressionally authorized minimum flow requirements | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **WATER QUALITY MEASURE NUMBER AND DESCRIPTION** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **105.** Construct water temperature control tower | – | – | – | – | – | – | – | – | – | - | – | – | X |
| **166**. Use regulating outlets for temperature management | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **174.** Structural improvements to reduce TDG | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **479**. Foster fish ladder temperature improvement | – | – | – | – | – | – | – | – | – | X | – | – | – |
| **721**. Use spillway for surface spill in summer | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **DOWNSTREAM PASSAGE MEASURE NUMBER AND DESCRIPTION** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **40.** Deeper fall reservoir drawdowns for downstream fish passage than under current conditions | – | – | – | – | – | - | – | X[1] | – | – | X[1] | – | – |
| **392**. Construct structural downstream fish passage | – | – | – | – | X | – | – | – | – | X | – | – | X |
| **714.** Pass water over spillway in spring for downstream fish passage | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **720**. Spring reservoir drawdown for downstream fish passage | – | – | – | – | – | – | – | X[1] | – | – | – | – | – |

| PROJECT/DAM | FRN | CTG | DOR | DEX | LOP | FCR | HCR | CGR | BLU | FOS | GPR | BCL | DET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **UPSTREAM PASSAGE MEASURE NUMBER AND DESCRIPTION** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **52.** Provide Pacific lamprey passage and infrastructure | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **639**. Restore upstream and downstream passage at drop structures | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **722**. Construct adult fish facility | – | – | – | – | – | – | – | – | – | – | X | – | – |
| **Measures Common to All Alternatives** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **384**. Gravel augmentation | – | – | – | – | – | – | – | X | X | X | – | X | – |
| **719.** Adapt Hatchery Program | – | – | – | X | X | X | X | X | X | X | X | X | X |
| **9.** Maintain revetments considering nature-based engineering or alter revetments for aquatic ecosystem restoration | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] | X[2] |
| **726**. Maintenance of existing and new fish release sites above dams | – | – | – | – | X | X | X | X | – | X | X | X | X |
| Fall Creek drawdown | – | – | – | – | – | X | – | – | – | – | – | – | – |
| Continued operation of existing Adult Fish Facilities | – | – | – | X | – | X | – | X | – | X | – | X | – |
| Maintenance of WVS facilities | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Adaptive Management | X | X | X | X | X | X | X | X | X | X | X | X | X |

[1]Draw down to DT. Requires structural modification to the DT.

[2]Basin-wide including Willamette River

### 2.4.12 Summary of measures in the action alternatives

Table 2.4-14 summarizes which measure appear in each of the action alternatives.

**Table 2.4-14. Summary of Measures under each Alternative**

| MEASURES | Alt 1 | Alt 2A | Alt 2B | Alt 3A | Alt 3B | Alt 4 | Alt 5 |
|---|---|---|---|---|---|---|---|
| Near-Term Operations Measure | | X | X | X | X | X | X |
| **FLOW MEASURES** | | | | | | | |
| 30a. Integrated temperature and habitat flow regime | | X | X | X | X | X | |
| 30b. Integrated temperature and habitat flow regime | | | | | | | X |
| 304. Augment instream flows by using the power pool | X | X | X | X | X | X | X |

| MEASURES | Alt 1 | Alt 2A | Alt 2B | Alt 3A | Alt 3B | Alt 4 | Alt 5 |
|---|---|---|---|---|---|---|---|
| 718. Augment instream flows by using inactive pool | X | X | X | X | X | X | X |
| 723. Reduce minimum flows to Congressionally authorized minimum flow requirements | X | | | | | | |
| **WATER QUALITY MEASURES** | | | | | | | |
| 105. Construct water temperature control tower | X | X | X | | | X | X |
| 166. Use Regulating Outlets for Temperature Management | X | X | X | X | X | X | X |
| 174. Structural improvements to reduce TDG | | | | | | X | |
| 479. Foster Fish Ladder Temperature Improvement | X | X | X | | X | X | X |
| 721. Use spillway for surface spill in summer | X | X | X | X | | X | X |
| **DOWNSTREAM PASSAGE MEASURES** | | | | | | | |
| 40. Deeper fall reservoir drawdowns for downstream fish passage | X | X | X | X | X | | X |
| 392. Construct structural downstream fish passage | X | X | X | | | X | X |
| 714. Pass water over spillway in spring for downstream fish passage | X | X | X | X | X | | X |
| 720. Spring reservoir drawdown for downstream fish passage | | | X | X | X | | X |
| **UPSTREAM PASSAGE MEASURES** | | | | | | | |
| 52. Provide Pacific lamprey passage and infrastructure | X | X | X | X | X | X | X |
| 639. Restore upstream and downstream passage at drop structures | | | | | | X | |
| 722. Construct adult fish facility | X | X | X | X | X | X | X |
| **Measures Common to All Alternatives** | | | | | | | |
| 384. Gravel Augmentation | X | X | X | X | X | X | X |
| 719. Adapt Hatchery Program | X | X | X | X | X | X | X |

| MEASURES | Alt 1 | Alt 2A | Alt 2B | Alt 3A | Alt 3B | Alt 4 | Alt 5 |
|---|---|---|---|---|---|---|---|
| 9. Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration | X | X | X | X | X | X | X |
| 726. Maintenance of existing and new fish release sites above dams | X | X | X | X | X | X | X |
| Fall Creek Drawdown | X | X | X | X | X | X | X |
| Continued Operation of Existing Adult Fish Facilities | X | X | X | X | X | X | X |
| Maintenance of WVS Facilities | X | X | X | X | X | X | X |
| Adaptive Management | X | X | X | X | X | X | X |

# CHAPTER 3 - AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

This chapter presents both the affected environment and environmental consequences for resources that could be affected by the Proposed Action and alternatives. The following resources were not analyzed and are dismissed from further analysis for the following reasons.

- Flood Risk – the U.S. Army Corps of Engineers (USACE) considered but dismissed flood risk from the analysis after development of the final array of alternatives when USACE confirmed that each alternative carried forward in the analysis would have not increase the levels of flood risk when compared to current operations and management levels of flood risk.
- Navigation and River Transportation – USACE considered but dismissed navigation and river transportation from the analysis because authorized flows for navigation serve the dual purpose of also meeting water quality standards; therefore, impacts to navigation, due to the availability or lack thereof of water to support these flows, are analyzed in the water quality analysis. Further analysis of impacts to navigation would be redundant.
- Transportation – USACE considered but dismissed ground transportation from the analysis because that effects on traffic would be negligible to minor throughout and could only be discussed very generically due to the programmatic level of analysis and lack of specifics. Ground transportation impacts for actions requiring construction will be assessed under subsequent tiered analysis.

## 3.1 METHODOLOGY

Sections 3.2 through 3.24 discuss the resources analyzed. The affected environment section for each of these resources defines the bounds of the area of analysis that could be affected by the Proposed Action and alternatives; it also summarizes the current physical, biological, social, and economic conditions for that resource area. The affected environment describes the elements or components of the resource that may be potentially affected by the Proposed Action and alternatives.

The environmental consequences section for each resource area considers how the condition of a resource would change as a result of implementing each of the alternatives. These potential effects are described in terms of types (direct, indirect, beneficial, adverse). These types of effects are further described using evaluation criteria or significance criteria including context and intensity, as well as effect factors including magnitude (how much), duration (how long), and extent (how big or how far). The types of effects are defined in Section 3.1.2and the development of evaluation criteria is described in Section 3.1.3 below. For each resource, the effects analysis is performed using a framework that follows the logical sequence of analytical steps below.

1. **Types of Effects –** Determine the types of effects that could occur with the implementation of individual measures or the suite of measures under each alternative. These could include direct, indirect, beneficial, and adverse effects.

2. **Evaluation Criteria** – Apply the evaluation criteria to determine the effect factors and scale from all effect-causing measures. The evaluation criteria, including significance, are defined for each resource in the respective methodology section.

3. **Effects Analysis by Alternative –** Combine the types of effects, effect factors (magnitude, extent, duration), and scale for each effect factor under each alternative. Compare effects between alternatives.

### 3.1.1 Types of Effects

According to the Council on Environmental Quality's (CEQ) National Environmental Policy Act (NEPA) Regulations at 40 Code of Federal Regulations (CFR) §§ 1500-1508 (1978), direct and indirect effects are defined as:

**Direct effects:** Effects that are caused by the action and occur at the same time and place (1508.8[a]). Examples include filling a wetland or digging up an archaeological site.

**Indirect effects:** Effects that are caused by the action and occur later in time or are farther removed in distance but are still reasonably foreseeable. Indirect effects also include "induced changes" in the human and natural environments (1508.8[b]). Examples of an indirect effects include causing economic change in a community that changes the environment over the long run (through development, increased taxes, etc.) or causing turbidity (a direct effect on water quality) in spawning grounds which in turn increases sedimentation which may damage next year's hatch of salmonids (an indirect biological effect).

Identified effects may be either adverse or beneficial. The CEQ Guidelines that govern NEPA implementation describe the need for identifying and differentiating between adverse and beneficial effects, but do not offer a definition of these terms. This Draft PEIS considers both adverse and beneficial effects as defined below:

**Adverse effects:** Those effects having a negative and harmful effect on the analyzed resource. An adverse impact causes a change that moves the resource away from a desired condition or detracts from its appearance or condition.

**Beneficial effects:** Those effects having a positive and supportive effect on the analyzed resource. A beneficial impact constitutes a positive change in the condition or appearance of the resource or a change that moves the resource toward a desired condition.

### 3.1.2 Evaluation Criteria for Potential Effects

Evaluation criteria (or significance criteria) provide a structured framework for assessing effects, supporting conclusions regarding the significance of effects, and comparing effects between alternatives.

#### *3.1.2.1 Context and Intensity*

As defined in 40 CFR 1508.27, determining the significance of effects requires a consideration of both context and intensity. Context means that the significance of an action must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality. Short-, medium- and long-term effects are all relevant. Intensity refers to the severity or magnitude of the effect. See 40 CFR 1508.27 for the list of factors that can contribute to the intensity of an impact.

The primary purpose of significance ratings in the NEPA process is to ascertain whether a lead agency should prepare an Environmental Impact Statement (EIS) (or Programmatic EIS [PEIS]) and Record of Decision (ROD), as opposed to a less time-consuming and less in-depth Environmental Assessment (EA) and Finding of No Significant Impact (FONSI). In the present case, USACE has already determined that a PEIS will be prepared because of the high potential for significant or major effects. This PEIS details where significant (and non-significant) effects would occur.

#### *3.1.2.2 Effect Factors and Scale*

For this Draft PEIS, USACE developed evaluation criteria for each resource by defining effect factors and the scale of these effect factors. The effect factors considered include the magnitude (how much), extent (how big or how far), and duration (how long or how often). The scale for the magnitude of effects includes negligible, minor, moderate, and major or significant. The scale for extent includes small, medium, and large or local, regional, and state-wide. The scale for duration includes short term, medium term, and long-term (permanent, continuous, or recurring).

While magnitude and extent vary for each resource, the duration of measures do not.

Short-, medium-, and long-term are defined below.

**Short-term:** Alteration lasts for the duration of the small construction project and can be temporary or is continuous for less than 2 years.

**Medium-term:** Alteration is limited to the duration of large construction projects and is continuous for a period of 2-5 years.

**Long-term:** Alteration is permanent or lasts continuously beyond operation changes or the completion of all construction projects; the alteration recurs at regular intervals (e.g., deep drawdowns that occur for a 3-week period in the fall and/or spring); or the alteration occurs intermittently over the long term.

The duration(s) for each measure is shown in the below table, and the measures that could have effects on specific resources are discussed in the appropriate section. Note that the following abbreviations for the WVS projects are used in the table:

- FRN – Fern Ridge;
- CTG – Cottage Grove;
- DOR – Dorena;
- DEX – Dexter;
- LOP – Lookout Point;
- FCR – Fall Creek;
- HCR – Hills Creek;
- CGR – Cougar;
- BLU – Blue River;
- FOS – Foster;
- GPR – Green Peter;
- BCL – Big Cliff; and
- DET – Detroit.

**Table 3.1-1. Duration(s) of Measures**

| Alternative and Action Location | Duration of Construction Activity | Duration of Operational Activity |
|---|---|---|
| **Measures common to all action alternatives** | **–** | **–** |
| 384. Gravel augmentation below dams | – | – |
| North Santiam, South Santiam, and McKenzie River sub-basins below BCL, FOS, BLU, and CGR dams | Short term | N/A |
| 719. Adapt hatchery program | – | – |
| North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins, including BCL, DET, GPR, FOS, BLU, CGR, DEX, LOP, FCR, and HCR | N/A | Long-term permanent |
| 9. Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration | – | – |
| North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins, including BCL, DET, GPR, FOS, CGR, LOP, FCR, and HCR | Short term | N/A |
| 726. Maintenance of existing and new fish release sites above dams | – | – |
| Basin-wide | Short term | N/A |
| **Existing operations continued forward** | **–** | **–** |
| Fall Creek Drawdown | – | – |
| FCR under all alternatives | N/A | Long-term recurring |
| Continued Operation of Existing Adult Fish Facilities | – | – |

| Alternative and Action Location | Duration of Construction Activity | Duration of Operational Activity |
|---|---|---|
| DEX, CGR, FOS, FCR, and Minto (downstream of BCL) | N/A | Long-term permanent |
| Operation, Maintenance, Repair, Replacement and Rehabilitation | – | – |
| Basin-wide under all alternatives | Scheduled/routine maintenance: Short term<br><br>Major maintenance and rehabilitation: Medium term | Long term intermittent |
| **Measures unique to specific alternatives** | **–** | **–** |
| 479. Foster Fish Ladder Temperature Improvement | **–** | **–** |
| 1, 2A, 2B, 4, 5: FOS | Medium-term | Long-term permanent |
| 105. Construct water temperature control tower | – | – |
| **1:** *DET, *GPR, *LOP<br>2A, 2B, and 5: DET<br>**4:** *DET, HCR, *LOP | Medium-term | Long-term permanent |
| 166. Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams | – | – |
| **2A, 2B, and 5:** GPR<br>**3A** and **3B:** DET, GPR, LOP<br>**4:** GPR | N/A | Long-term permanent |
| 721. Use spillway for surface spill in summer | – | – |
| **2A, 2B, 4, 5:** GPR<br>**3A** and **3B:** *BLU, DET, FOS, GPR, *HCR, LOP | *Short-term (BLU and HCR only) | Long-term permanent |
| 174. Structural improvements to reduce total dissolved gas | – | – |
| **1** and **4:** CGR, DET, DEX, FOS, GPR, LOP | Medium-term | Long-term permanent |
| 718. Augment instream flows by using the inactive pool | – | – |
| **1, 3A, 3B, 4:** BLU, CTG, DOR, FCR<br>2A, 2B, and 5: BLU; FCR | N/A | Long-term permanent |
| 304. Augment instream flows by using the power pool | – | – |
| **1, 2A, 3A, 4:** CGR, DET, GPR, HCR, LOP<br>**2B, 3B, and 5:** DET, GPR, HCR, LOP | N/A | Long-term permanent |
| 723. Reduce minimum flows to Congressionally authorized minimum flow requirements | – | – |

| Alternative and Action Location | Duration of Construction Activity | Duration of Operational Activity |
|---|---|---|
| **1:** Basin-wide (all dams) | N/A | Long-term permanent |
| 30a. Integrated temperature and habitat flow regime | – | – |
| **2A, 2B, 3A, 3B, 4:** Basin-wide (all dams) | N/A | Long-term permanent |
| 30b. Refined Integrated temperature and habitat flow regime | – | – |
| **5:** Basin-wide (all dams) | N/A | Long-term permanent |
| 639. Restore upstream and downstream passage at drop structures | – | – |
| **1** and **4:** FRN | Short-term | Long-term permanent |
| 722. Construct adult fish facility | – | – |
| **1, 2A, 2B, and 5:** GPR<br>**3A** and **3B:** BLU, GPR, HCR<br>**4:** HCR | Medium-term | Long-term permanent |
| 52. Provide Pacific lamprey passage and infrastructure | – | – |
| **1:** FRN, GPR<br>**2A, 2B, and 5:** GPR<br>**3A** and **3B:** BLU, GPR, HCR<br>**4:** FRN, HCR | Short-term | Long-term permanent |
| 392. Construct structural downstream fish passage | – | – |
| **1:** DET, *FOS, GPR, LOP<br>**2A:** CGR, DET, *FOS, LOP<br>**2B and 5:** DET, *FOS, LOP<br>**4:** CGR, DET, *FOS, HCR, LOP | Medium-term<br>*short-term (FOS only) | Long-term permanent |
| 40. Deeper fall reservoir drawdowns for fish passage | – | – |
| **2A:** GPR<br>**2B and 5:** *CGR, GPR<br>**3A:** BLU, CGR, DET, GPR, HCR, LOP<br>**3B:** BLU, *CGR, DET, GPR, HCR, LOP | *Medium-term | Long-term recurring |
| 720. Spring reservoir drawdown for downstream fish passage | – | – |
| **2B:** *CGR<br>**3A:** *CGR, DET, LOP<br>**3B:** *CGR, GPR, HCR | *Medium-term | Long-term permanent |
| 714. Pass water over spillway in spring for fish passage | – | – |
| **2A, 2B, and 5:** GPR<br>**3A:** BCL, DEX, FCR, GPR, *HCR<br>**3B:** BCL, DET, DEX, LOP | *Short-term | Long-term permanent |

| Alternative and Action Location | Duration of Construction Activity | Duration of Operational Activity |
|---|---|---|
| Suite of Near-term Operations | – | – |
| **2A, 2B, 3A, 3B, 4, and 5:** LOP, FCR, HCR, CGR, FOS, GPR, BCL, DET | N/A | Long-term permanent |

Each section begins by presenting the methodology used to characterize potential effects. For each resource, the definitions of types of impacts that could occur (direct, indirect, beneficial, adverse), consideration of both context and intensity (as defined in 40 CFR 1508.27), and the evaluation criteria (including magnitude, geographic extent, and duration) used to arrive at an overall conclusion of effects are explained.

### 3.1.3 Structure of the Effects Analysis by Resource

The analysis for each resource follows one of two different approaches based on whether it was more logical to discuss effects by measure(s) on a smaller scale, or effects by geographic region (basin-wide and/or sub-basins) on a larger scale. Regardless of the approach taken, each environmental consequences section begins with a detailed description of the methodology used for that resource.

The first approach, and the method that most of the resources use, analyzes the combined effects of all the measures under each alternative by geographic region, both by sub-basin and basin wide. The macroscopic approach was more applicable to resources that would have broader system-wide effects, such as hydrologic processes, river mechanics and geomorphology, and geology and soils. Analyses only discuss effects for relevant geographic regions (e.g., water supply only considers the Santiam and McKenzie sub-basins rather than all sub-basins).

The second approach analyzes the effects from each measure and groups analyses by measures that would have similar effects. The analysis under each action alternative refers up to the discussion of effects by measure(s) subsection but discusses effects by dam/reservoir as applicable. The analysis by measure(s) was more applicable to resources that would have smaller and more discrete effects that were not logical to discuss by geographic region, such as noise, visual resources, and hazardous materials. The approach used for each resource topic is shown below in Table 3.1-2.

**Table 3.1-2. Structure of the Effects Analysis by Resource**

| Section | Resource Topic | Combination of Individual Measures Analysis | Suite of Measures Analysis (Geographic Context) |
|---|---|---|---|
| 3.2 | Hydrologic Processes and River Infrastructure | – | X<br>(Basin-wide and sub-basins) |
| 3.3 | River Mechanics and Geomorphology | – | X<br>(Basin-wide and sub-basins) |

| Section | Resource Topic | Combination of Individual Measures Analysis | Suite of Measures Analysis (Geographic Context) |
|---|---|---|---|
| 3.4 | Geology and Soils | – | X<br>(Basin-wide and sub-basins) |
| 3.5 | Water Quality | – | X<br>(Basin-wide and sub-basins) |
| 3.6 | Vegetation (including ESA/sensitive species and critical habitat) | – | X<br>(Basin-wide and sub-basins) |
| 3.7 | Wetlands | – | X<br>(Basin-wide and sub-basins) |
| 3.8 | Fish, Aquatic Invertebrates, and Aquatic Habitat (including ESA/sensitive species and critical habitat) | – | X<br>(Basin-wide and sub-basins) |
| 3.9 | Wildlife, Birds, and Terrestrial Habitat (including ESA/sensitive species and critical habitat) | – | X<br>(Basin-wide and sub-basins) |
| 3.10 | Air Quality | X | – |
| 3.11 | Socioeconomics | X | – |
| 3.12 | Power and Transmission | – | X<br>(Basin-wide and sub-basins) |
| 3.13 | Water Supply (Irrigation, Municipal, and Industrial) | – | X<br>(Basin-wide and Santiam and McKenzie sub-basins) |
| 3.14 | Recreation | X | – |
| 3.15 | Land Use | X | – |
| 3.16 | Hazardous Materials | X | – |
| 3.17 | Public Health and Safety – Hazardous Algal Blooms | X | – |
| 3.18 | Public Health and Safety – Hazardous, Toxic, and Radioactive Waste | X | – |
| 3.19 | Public Health and Safety – Drinking Water | X | – |
| 3.20 | Environmental Justice | X | – |
| 3.21 | Cultural Resources | X | – |
| 3.22 | Visual Resources | X | – |
| 3.23 | Noise | X | – |
| **3.24** | Tribal Resources | – | X |

### 3.1.4 Level of analysis in this PEIS

Programmatic analysis of the resources in this chapter is at a broad and macroscopic scale and scope. This analysis of the resources focuses on the effects that are relevant at the broad scale and would factor into the decision to select the suite of measures to include in the preferred alternative. These broad effects of the proposed action serve as a starting point for further site-specific evaluation of direct, indirect, and cumulative effects – effectively laying the groundwork for subsequent tiered analyses. Tiering means taking general, preliminary analyses from a programmatic document and adding to them in a subsequent EA or EIS when more detail and specifics about the project are known.

The level of analysis in this PEIS depends on the amount of information currently available and whether detailed design and construction will be needed. The PEIS fully assesses the effects of most operational measures that do not require detailed design and construction to implement immediately. Some operational measures would eventually require dam modifications to address operational and dam safety concerns and may thus need further analysis. These measures are listed in Tables 3.1-3 and 3.1-4, respectively, and discussed below in Section 3.1.5.1 (Operational Measures). If USACE determines that this PEIS has not sufficiently evaluated the potential environmental effects of an action, then tiered NEPA analysis will be required – probably for some but not all resources. For measures that would require site-specific construction, USACE would perform subsequent NEPA evaluations tiered to this PEIS, as applicable. During this subsequent NEPA phase, the effects analysis would be informed by the site-specific designs prepared at that time for measures requiring construction. Subsequent analysis would include appurtenant or ancillary implementation features or activities, such as use of construction equipment, site preparation, access, staging, and material storage and transfer facilities. These measures are listed in Table 3.1-5 and discussed below in Section 3.1.5.2 (Structural Measures). Typical descriptions of several activities that could occur during implementation of the measures are summarized in Section 2.2.6. Subsequent NEPA analysis tiered to this PEIS will include public review and comment opportunities.

#### *3.1.4.1 Operational Measures*

This Draft PEIS fully assesses the effects of most operational measures that do not require detailed design and construction to implement immediately. The PEIS has taken the required “hard look” at the potential environmental effects of these measures, and further NEPA evaluation will not be necessary. These measures are shown below in Table 3.1-3. If USACE determines that this PEIS has not sufficiently evaluated the potential environmental effects of an action, then tiered NEPA analysis will be required – probably for some but not all resources.

**Table 3.1-2. Operational measures with no further site- or project- specific NEPA analysis required**

| Measures | Locations[1] |
|---|---|
| **Flow Measures** | – |
| 30b. Refined Integrated temperature and habitat flow regime | FRN, CTG, DOR, DEX, LOP, FCR, HCR, CGR, BLU, FOS, GPR, BCL, DET |
| 304. Augment instream flows by using the power pool | LOP, HCR, CGR, GPR, DET |
| 718. Augment instream flows by using inactive pool | CTG, DOR, FCR, BLU |
| 723. Reduce minimum flows to Congressionally authorized minimum flow requirements | FRN, CTG, DOR, DEX, LOP, FCR, HCR, CGR, BLU, FOS, GPR, BCL, DET |
| **Water Quality Measures** | – |
| 166. Use Regulating Outlets for Temperature Management | LOP, GPR |
| 721. Use spillway for surface spill in summer | LOP, GPR, DET |
| **Downstream Passage Measures** | – |
| 40. Deeper fall reservoir drawdowns for downstream fish passage for the drawdown operation to the Regulating Outlet | LOP, HCR, CGR, BLU, GPR, DET |
| 714. Pass water over spillway in spring for downstream fish passage | DEX, LOP, FCR, GPR, BCL, DET |
| 720. Spring reservoir drawdown for downstream fish passage | LOP, CGR, DET |
| **Measures Common to All Alternatives** | – |
| 719. Adapt Hatchery Program | North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins |
| Fall Creek Drawdown | FCR |
| Continued Operation of Existing Adult Fish Facilities | North Santiam, South Santiam, South Fork McKenzie, and Middle Fork Willamette sub-basins |
| Scheduled/Routine Maintenance of WVS Facilities | Basin-wide |

[1]: Dam Abbreviations

BCL – Big Cliff; BLU – Blue River; CGR – Cougar; CTG – Cottage Grove
DET – Detroit; DEX – Dexter; DOR – Dorena; FCR – Fall Creek
FOS – Foster; FRN – Fern Ridge; GPR – Green Peter; HCR – Hills Creek
LOP – Lookout Point

It is assumed that routine Operations and Maintenance (O&M, as described in Section 1.8.2 and Appendix A) will not result in impacts to the environment, as they are mostly sited within existing structural facilities. Therefore, impacts associated with these actions are not analyzed further in the effects analysis (Chapter 3). However, each action is routinely assessed for environmental compliance prior to implementation, and any action that may result in impacts to the human environment will undergo additional analysis under the tiered NEPA process described in Chapter 7.

Some operational measures would eventually require dam modifications to address operational and dam safety concerns and may need further analysis. If USACE determines that this PEIS has not sufficiently evaluated the potential environmental effects of an action, then tiered NEPA analysis will be required – probably for some but not all resources. These measures are shown in Table 3.1-4.

**Table 3.1-3. Operational measures that would require site- or project- specific NEPA analysis**

| Measures | Locations |
| --- | --- |
| **Water Quality** | **–** |
| 721. Use spillway for surface spill in summer | HCR, BLU |
| **Downstream Passage Measures** | – |
| 40. Deeper fall reservoir drawdowns for downstream fish passage for the drawdown operation to the DT | CGR |
| 714. Pass water over spillway in spring for downstream fish passage | HCR, BLU |
| 720. Spring reservoir drawdown for downstream fish passage for the drawdown operation to the DT | CGR |
| **Measures Common to All Alternatives** | – |
| 726. Maintenance of existing and new fish release sites above dams | North Santiam, South Santiam, South Fork McKenzie, and Middle Fork Willamette sub-basins |
| Major Maintenance and Rehabilitation of WVS Facilities | Basin-wide |

### *3.1.4.2 Structural Measures*

For structural measures that would require site-specific construction, limited analysis and a range of potential effects of the potential site-specific implementation of the general construction activities are included in the effects analysis for each resource in this PEIS. Site-specific alternatives development and evaluation will determine the actual features and activities included during a subsequent analysis tiered to this PEIS, when site-specific design objectives and constraints will be addressed. During this subsequent NEPA phase, the effects analysis would be informed by the site-specific designs performed at that time for measures requiring construction. Subsequent analysis would include appurtenant or ancillary implementation features or activities, such as construction equipment, site preparation, access, staging, and material storage and transfer facilities. Typical descriptions of several activities that could occur during implementation of the measures are summarized in Appendix A and 7.2.2.3 (Structural measures with subsequent tiered NEPA analysis).

The following measures in Table 3.1-5, discussed in Chapter 2 and in Appendix A, are analyzed generally in this PEIS, but would require site-specific design and construction and therefore would be analyzed in more detail in the tiered EA or EIS.

**Table 3.1-4. Structural measures that would require site- or project- specific NEPA analysis**

| Measures | Locations |
|---|---|
| **Water Quality Measures** | – |
| 105. Construct water temperature control tower | LOP, HCR, DET |
| 479. Foster Fish Ladder Temperature Improvement | FOS |
| 174. Structural improvements to reduce TDG | DEX, LOP, CGR, FOS, GPR, DET |
| **Downstream Passage Measures** | – |
| 639. Restore upstream and downstream passage at drop structures | FRN |
| 392. Construct structural downstream fish passage | LOP, HCR, CGR, FOS, DET |
| **Upstream Passage Measures** | **–** |
| 52. Provide Pacific lamprey passage and infrastructure | FRN, HCR, BLU, GPR |
| 722. Construct adult fish facility | HCR, BLU, GPR |
| **Measures Common to All Alternatives** | – |
| 384. Gravel Augmentation | North Santiam, South Santiam, and McKenzie River Basins below Big Cliff, Foster, Cougar, and Blue River dams |
| 9. Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration | Basin-wide |

### 3.1.5 Climate Change

USACE developed a list of climate factors that were relevant to the WVS PEIS climate change assessment. These climate factors are discussed in more depth in Appendix F. The list of relevant climate change factors is summarized below:

1. Ambient air temperature change;
2. Water temperature change;
3. Precipitation changes;
4. Seasonal timing of flow peaks and volumes;
5. Low summer flow- shortage/volume/frequency;
6. Change in snowpack accumulation and spring freshet timing;
7. Reservoir evaporation/ reach evapotranspiration effects;
8. Wildfire intensity/frequency change; and
9. Wildfire impacts to water quality.

Each resource area topic qualitative determination, use the climate change assessment information provided in Appendix F as shown in Table 3.1-5.

**Table 3.1-5. Relevant climate factors analyzed in resource topics**

| Section | Resource Topic | Ambient temp (1) | Water temp (2) | Precipitation (3) | Flow peak and timing (4) | Summer low flow (5) | Spring snow melt (6) | Evapotranspiration (7) | Wildfire (8) | Wildfire effects (9) |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.2 | Hydrologic Processes | – | – | X | X | X | X | X | – | – |
| 3.3 | River Mechanics and Geomorphology | – | – | – | X | – | X | – | X | – |
| 3.4 | Geology and Soils | – | – | – | – | – | – | – | – | – |
| 3.5 | Water Quality | X | X | X | X | X | X | X | X | X |
| 3.6 | Vegetation (including ESA/sensitive species and critical habitat) | X | X | X | X | X | X | X | X | X |
| 3.7 | Wetlands | X | | X | X | X | X | X | | X |
| 3.8 | Fish, Aquatic Invertebrates, and Aquatic Habitat (including ESA/sensitive species and critical habitat) | X | X | X | X | X | X | X | X | X |
| 3.9 | Wildlife, Birds, and Terrestrial Habitat (including ESA/sensitive species and critical habitat) | X | X | X | X | X | X | X | X | X |
| 3.10 | Air Quality | X | – | – | – | – | – | – | X | – |
| 3.11 | Socioeconomics | X | X | X | X | X | X | X | X | X |
| 3.12 | Power and Transmission | X | – | X | X | X | X | X | – | – |
| 3.13 | Water Supply (Irrigation, Municipal, and Industrial) | – | – | X | X | X | – | – | – | – |
| 3.14 | Recreation | X | X | X | X | X | X | X | X | X |
| 3.15 | Land Use | – | – | – | – | X | – | – | X | – |
| 3.16 | Hazardous Materials | X | – | X | – | X | – | – | X | – |

| Section | Resource Topic | Ambient temp (1) | Water temp (2) | Precipitation (3) | Flow peak and timing (4) | Summer low flow (5) | Spring snow melt (6) | Evapotranspiration (7) | Wildfire (8) | Wildfire effects (9) |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.17 | Public Health and Safety – Hazardous Algal Blooms | – | X | X | X | X | – | X | – | X |
| 3.18 | Public Health and Safety – Hazardous Materials | – | – | X | – | – | – | – | X | – |
| 3.19 | Public Health and Safety – Drinking Water | – | – | X | X | X | X | X | – | X |
| 3.20 | Environmental Justice | X | X | X | X | X | X | X | X | X |
| 3.21 | Cultural Resources | – | – | – | X | X | – | – | X | – |
| 3.22 | Visual Resources | – | X | X | X | X | X | X | X | X |
| 3.23 | Noise | – | – | – | – | – | – | – | X | – |
| 3.24 | Tribal Resources | X | X | X | X | X | X | X | X | X |

#### *3.1.5.1 Near-term operational measure analysis*

The Near-term Operations Measure is evaluated qualitatively for effects over the period of analysis for this Draft PEIS (30 years) with an intent to capture the maximum range of impacts. The Near-term Operations Measure is not included in the No Action Alternative (NAA) because its initiation occurs after the period of record that defines the NAA. The Near-term Operations Measure is not included in Alternative 1 as these operations are counter to the objective of the alternative to maximize storage; however, this measure is included in Alternatives 2A, 2B, 3A, 3B, 4, and 5. The analysis of effects is discussed in each resource area under Alternative 2A and then referenced under each subsequent alternative as the maximum range of effects would be the same across all other action alternatives.

Similarly, projected climate change effects to/of the Near-term Operations Measure are not analyzed quantitively. The future projections of relevant climate change variables are the same for the Near-Term Operations Measure and the action alternatives. The Near-term Operations Measure is not likely to be any more sensitive to expected climate change factors than the other alternatives or measures. The future hydrologic and hydro-climate trends that are likely to impact the range of the Draft PEIS alternatives in the WVS, including Near-term Operations Measure, are contained in Appendix F. Though unlikely, specific operations in the Near-term Operations Measure could conceivably be in effect from 2024 through 2050. The climate change factor trends cited in Section 3.1.5 would be experienced over the period of implementation.

Climate change effects associated with the Near-term Operations Measure are not analyzed because the projected near-term climate change effects experienced under the Near-term Operations Measure are the same as for other Draft PEIS alternatives. Alternatives would be executed at different times for different sites, depending upon individual implementation plans. Near term operations at a certain location may be in place for a relatively short amount of time, up to a maximum duration of 30 years. The Near-term Operations Measure may therefore experience changing climate over different time frames (e.g., 15 years versus 30). Additionally, the response to near-term climate change would be inherently a monitor centric based approach. From that standpoint, Near-term Operations Measure operational changes are inherently adaptable. Monitoring of climate change factor trends can inform adjustment, within the permissible constraints, of the Near-term Operations Measure parameters.

### 3.1.6 Summary of Environmental Consequences

A summary comparing the effects of each alternative by resource area is provided in Table 3.1-6. The categories of effects (i.e., minor adverse and major beneficial) shown in Table 3.1-7 are defined for each resource area in their associated detailed environmental consequences section in the methodology description.

**Table 3.1-6. Summary of overall indirect and direct effects to resources compared to the No Action Alternative**

| Resource Topic | NAA | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| 3.2 Hydrologic Processes and River Infrastructure | None/Negligible Effects<br><br>Maintains hydrology of WRB consistent with existing conditions, with the addition of increased releases for M&I water storage agreements. | Major Effects<br><br>Would have limited effects during an average or wet year in the WRB. Summer flows would sometimes be a bit higher than NAA but flow differences are minimal. Would alter storage in drier than average years, shifting flow releases from April to June into July through October. Would miss the current BiOp flow requirements more often, but those misses would occur earlier in the year during the April to June period. Later flow targets from July to October are met more frequently. | Major Effects<br><br>Lower spring flows in dry years and higher summer flows in nearly all years would have long term effects across the WRB. Reservoir elevations would be somewhat higher than the NAA.<br>Green Peter reservoir would have a fall drawdown resulting in more flow in the late summer and early fall in the South Santiam, Santiam, and Willamette downstream of the confluence with the Santiam. The WVS would also meet the mainstem Willamette River flow targets more often with higher Cougar storage levels, as compared to the NAA. | Major Effects<br><br>Lower spring flows in dry years and higher summer flows in nearly all years would have long term effects across the WRB. Flows would be lower than NAA flows in the year during the April to June period. Later flow targets from July to October would be met more frequently due to the additional accumulated stored water. Compared to NAA, the spring and early flows would be similar or somewhat lower across the WVS, so reservoir elevations would be somewhat higher than the NAA throughout the conservation season. Storage at Cougar is reduced resulting additional water released at other WVS reservoirs, notably in the Middle Fork of the Willamette River subbasin, to meet mainstem Willamette River flow targets. The flow target at Albany is missed more often in dry years as the larger WVS reservoirs reach their minimum elevations earlier in the year. | Major Effects<br><br>NAA flow targets and the lower Integrated Flow Regime flow targets would not be met across the WRB during an average flow year. These notably lower flows would have long term consequences across the WRB. Spring drawdowns at Detroit, Lookout Point and Cougar (to the regulating outlet) and the fall drawdown operations at Blue River, Hills Creek, Green Peter, Detroit, Lookout Point and Cougar are typically to the lowest level possible. The spring drawdown can inhibit refill of the reservoirs into the late winter and spring, limiting available water to augment flows downstream during the summer and fall. Releases during the during the spring can lower flows in the summer, especially during drier years. An average flow year would see Detroit and Cougar unable to contribute meaningfully to flow targets downstream. | Major Effects<br><br>Santiam subbasin summer flow would be well below the baseline and the adaptability of the WVS would be constrained by a reduced ability to refill during conservation season. All changes to the WRB would be long term. Spring drawdown operations are at Hills Creek, Green Peter and Cougar (to the diversion tunnel) and fall drawdown operations at Blue River, Hills Creek, Green Peter, Detroit, Lookout Point and Cougar are typically to lowest level possible. Both the spring and fall drawdowns at Cougar make use of the diversion tunnel leading to a much lower drawdown. The spring drawdown can inhibit refill of the reservoirs into the late winter and spring making less water available to augment flows downstream during the summer and fall. | Major Effects<br><br>The shift in releases of stored water to a different season would be very noticeable throughout the basin and would bring long term changes to the WRB. Would have limited effects during an average or wet year. Summer flows are sometimes a bit higher Would alter storage in drier than average years, shifting flow releases from April to June into July through October. Would result in less flow compared to the NAA earlier in the year during the April to June period. Later flow targets from July to October would be met more frequently Compared to Alternative 1, the flows are similar or higher across the WVS, so reservoir elevations would be somewhat lower than Alternative 1. | Major Effects<br><br>Lower spring flows in dry years and higher summer flows in nearly all years would have long term effects across the WRB. Flows would be lower than NAA flows in the year during the April to June period. Later flow targets from July to October would be met more frequently due to the additional accumulated stored water. Compared to NAA, the spring and early flows would be similar or somewhat lower across the WVS, so reservoir elevations would be somewhat higher than the NAA throughout the conservation season. Storage at Cougar is reduced resulting additional water released at other WVS reservoirs, notably in the Middle Fork of the Willamette River subbasin, to meet mainstem Willamette River flow targets. The flow target at Albany is missed more often in dry years as the larger WVS reservoirs reach their minimum elevations earlier in the year. |
| 3.3 River Mechanics and Geomorphology - | All Subbasins and Reservoirs: Negligible | Mainstem Willamette and Long Tom | Mainstem Willamette, Coast Fork, and Long | Coast Fork, and Long Tom Subbasins: Negligible change | Long Tom Subbasin: Negligible change | Long Tom Subbasin: Negligible change | Mainstem Willamette and Long Tom | Coast Fork, and Long Tom Subbasins: Negligible change |

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| *change in storage project head of reservoir sediment mobilization, trap efficiency, and shoreline exposure* | These processes would continue at magnitudes and rates similar to existing conditions. | Subbasins: Negligible change<br><br>Santiam, McKenzie, Middle Fork, and Coast Fork Subbasin storage projects: major changes in shoreline exposure due to changes in operational range and deeper drafts. | Tom Subbasins: Negligible change<br><br>Santiam, McKenzie, and Middle Fork Subbasin storage projects: major changes in shoreline exposure due to changes in operational range and deeper drafts.<br><br>Green Peter: moderate decreases in sediment trap efficiency and major changes in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir. | Santiam, McKenzie, and Middle Fork Subbasin storage projects: major changes in shoreline exposure due to changes in operational range and deeper drafts.<br><br>Green Peter: moderate decreases in sediment trap efficiency and major changes in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir.<br><br>Cougar: major changes with decreased sediment trapping efficiency and changes in head of reservoir sediment mobilization with sediment deposition deeper in the reservoir. | Detroit and Lookout Point: major decrease in sediment trapping efficiency, major change in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and major change in shoreline exposure with more shoreline exposed due to changes in operational range and deeper drafts.<br><br>Green Peter: moderate decrease in sediment trapping efficiency, major change in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and major change in shoreline exposure with more shoreline exposed due to changes in operational range and deeper drafts.<br><br>Cougar: moderate decrease in sediment trapping efficiency, major change in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and major change in shoreline exposure with more shoreline exposed due to changes in operational range and deeper drafts. | Detroit, Hills Creek, and Lookout Point: minor decrease in sediment trapping efficiency, major change in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and major change in shoreline exposure with more shoreline exposed due to changes in operational range and deeper drafts.<br><br>Green Peter and Cougar: major decrease in sediment trapping efficiency, major change in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and major change in shoreline exposure with more shoreline exposed due to changes in operational range and deeper drafts.<br><br>Blue River: minor decrease in sediment trapping efficiency, minor change in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and major change in shoreline exposure with more shoreline exposed due to changes in operational range and deeper drafts. | Subbasins: Negligible change<br><br>Santiam, McKenzie, Middle Fork, and Coast Fork Subbasin storage projects: major changes in shoreline exposure due to changes in operational range and deeper drafts. | Santiam, McKenzie, and Middle Fork Subbasin storage projects: major changes in shoreline exposure due to changes in operational range and deeper drafts.<br><br>Green Peter: moderate decreases in sediment trap efficiency and major changes in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir.<br><br>Cougar: major changes with decreased sediment trapping efficiency and changes in head of reservoir sediment mobilization with sediment deposition deeper in the reservoir. |

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| | | | | | Blue River: minor decrease in sediment trapping efficiency, minor change in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and major change in shoreline exposure with more shoreline exposed due to changes in operational range and deeper drafts.<br>Hills Creek: minor change in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and minor change in shoreline exposure with more shoreline exposed due to deeper drafts.<br><br>Dorena and Cottage Grove: major changes in shoreline exposure due to changes in operational range and deeper drafts. | Dorena and Cottage Grove: major changes in shoreline exposure due to changes in operational range and deeper drafts. | | |
| 3.3 River Mechanics and Geomorphology - *potential changes in sediment supply* | All Subbasins and Reservoirs: Negligible change in run-of-river reservoir and free-flowing reaches<br><br>These processes would continue at magnitudes and rates similar to existing conditions | Mainstem Willamette and Long Tom Subbasins: Negligible change<br><br>Santiam Subbasins: moderate increase in fine grained sediment supply into Big Cliff and Foster which may pass a minor increase in fine grained sediment downstream. | Mainstem Willamette, Coast Fork, and Long Tom Subbasins: Negligible change<br><br>North Santiam: moderate increase in fine grained sediment supply into the Big Cliff reservoir which may pass a minor increase in fine grained sediment downstream.<br>South Santiam: major increase in fine grained | Coast Fork, and Long Tom Subbasins: Negligible change<br><br>North Santiam: moderate increase in fine grained sediment supply into Big Cliff which may pass a minor increase in fine grained sediment downstream into the North Santiam free-flowing reach. | Long Tom Subbasin: Negligible change<br><br>Santiam Subbasins: major increase in fine grained sediment supply into the Big Cliff and Foster re-regulation projects which would partially settle in the pools and pass a moderate increase in fine grained sediment downstream. | Long Tom Subbasin: Negligible change<br><br>North Santiam: moderate increase in fine grained sediment supply into the Big Cliff re-regulation project which would partially settle in the pools and pass a minor increase in fine grained sediment downstream. | Mainstem Willamette and Long Tom Subbasins: Negligible change<br><br>Santiam Subbasins: moderate increase in fine grained sediment supply the Big Cliff and Foster re-regulation projects which may pass a minor increase in fine grained sediment downstream. | Coast Fork, and Long Tom Subbasins: Negligible change<br><br>North Santiam: moderate increase in fine grained sediment supply into Big Cliff which may pass a minor increase in fine grained sediment downstream into the North Santiam free-flowing reach. |

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| | | South Fork McKenzie: minor increase in fine grained sediment supply.<br><br>Blue River: moderate increase of fine-grained sediment supply into.<br><br>Middle Fork: moderate increase in fine grained sediment supply below Hills Creek and a minor increase in fine-grained sediment supply below Lookout Point entering Dexter Reservoir.<br><br>Row River and Coast Fork Willamette: Moderate increase in fine grained sediment supply. | sediment supply into Foster Reservoir from Green Peter which, partially settling in the Foster pool, may pass a moderate increase in fine grained sediment supply downstream into the South Santiam.<br><br>South Fork McKenzie: minor increase in fine grained sediment supply<br><br>Blue River: moderate increase of fine- grained sediment supply<br><br>Middle Fork: moderate increase in fine grained sediment supply below Hills Creek and a minor increase in fine-grained sediment supply below Lookout Point entering Dexter Reservoir. | South Santiam: major increase in fine grained sediment supply into Foster from Green Peter which may partially settle in the Foster pool and pass a moderate increase in fine grained sediment supply downstream into the.<br><br>South Fork McKenzie: major increase in fine grained sediment supply.<br><br>Blue River: moderate increase of fine-grained sediment supply.<br><br>Middle Fork: moderate increase in fine grained sediment supply below Hills Creek and a minor increase in fine-grained sediment supply below Lookout Point entering Dexter Reservoir.<br><br>Mainstem Willamette: moderate increase in fine grained sediment supply from the McKenzie River due to changes in operations at Cougar Dam. | South Fork McKenzie and Blue River: moderate increase in fine grained sediment supply<br><br>Middle Fork: major increase in fine grained sediment supply into the Dexter re-regulation project which would partially settle in the pool and pass a moderate increase in fine grained sediment downstream into the Middle Fork Willamette free-flowing reach.<br><br>Row River and Coast Fork Willamette: moderate increase in fine grained sediment supply<br><br>Mainstem Willamette: minor increase in fine grained sediment supply into the Mainstem Willamette River coming from changes in operation in the Middle and Coast Forks of the Willamette and McKenzie subbasins. | South Santiam: major increase in fine grained sediment supply into the Foster which would partially settle in the pools and in turn may pass a moderate increase in fine grained sediment downstream.<br><br>South Fork McKenzie: major increase in fine grained sediment supply<br><br>Blue river: moderate increase of fine-grained sediment supply.<br><br>Dexter: major increase in fine grained sediment supply which would partially settle in the pool and pass a moderate increase in fine grained sediment downstream into the Middle Fork Willamette free-flowing reach. There is potential for a minor increase in fine grained supply into the Middle Fork Willamette from Hills Creek reservoir.<br><br>Row River and Coast Fork Willamette: moderate increase in fine grained sediment supply<br><br>Mainstem Willamette: minor increase in fine grained sediment supply into the Mainstem Willamette River coming | South Fork McKenzie: minor increase in fine grained sediment supply.<br><br>Blue River: moderate increase of fine-grained sediment supply into.<br><br>Middle Fork: moderate increase in fine grained sediment supply below Hills Creek and a minor increase in fine-grained sediment supply below Lookout Point entering Dexter Reservoir.<br><br>Row River and Coast Fork Willamette: Moderate increase in fine grained sediment supply. | South Santiam: major increase in fine grained sediment supply into Foster from Green Peter which may partially settle in the Foster pool and pass a moderate increase in fine grained sediment supply downstream into the.<br><br>South Fork McKenzie: major increase in fine grained sediment supply.<br><br>Blue River: moderate increase of fine-grained sediment supply.<br><br>Middle Fork: moderate increase in fine grained sediment supply below Hills Creek and a minor increase in fine-grained sediment supply below Lookout Point entering Dexter Reservoir.<br><br>Mainstem Willamette: moderate increase in fine grained sediment supply from the McKenzie River due to changes in operations at Cougar Dam. |

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| | | | | | | from changes in operation in the Middle and Coast Forks of the Willamette and McKenzie subbasins. | | |
| 3.3 River Mechanics and Geomorphology - *geomorphic change* | All Subbasins and Reservoirs: Negligible change.<br><br>These processes would continue at magnitudes and rates similar to existing conditions | Gravel augmentation downstream of Big Cliff, Foster, Blue River, and Cougar Dams will modify the geomorphology of the North Fork Santiam, South Fork Santiam, and McKenzie by creating mobile gravel in-river features. | Gravel augmentation downstream of Big Cliff, Foster, Blue River, and Cougar Dams will modify the geomorphology of the North Fork Santiam, South Fork Santiam, and McKenzie by creating mobile gravel in-river features. | Gravel augmentation downstream of Big Cliff, Foster, Blue River, and Cougar Dams will modify the geomorphology of the North Fork Santiam, South Fork Santiam, and McKenzie by creating mobile gravel in-river features. The potential major increase in sediment in fine grained sediment supply form Cougar reservoir may deposit substantial fines in the South Fork McKenzie. | Gravel augmentation downstream of Big Cliff, Foster, Blue River, and Cougar Dams will modify the geomorphology of the North Fork Santiam, South Fork Santiam, and McKenzie by creating mobile gravel in-river features. The potential major increase in sediment in fine grained sediment supply form Cougar reservoir may deposit substantial fines in the South Fork McKenzie. | Gravel augmentation downstream of Big Cliff, Foster, Blue River, and Cougar Dams will modify the geomorphology of the North Fork Santiam, South Fork Santiam, and McKenzie by creating mobile gravel in-river features. The potential major increase in sediment in fine grained sediment supply form Cougar reservoir may deposit substantial fines in the South Fork McKenzie. | Gravel augmentation downstream of Big Cliff, Foster, Blue River, and Cougar Dams will modify the geomorphology of the North Fork Santiam, South Fork Santiam, and McKenzie by creating mobile gravel in-river features. | Gravel augmentation downstream of Big Cliff, Foster, Blue River, and Cougar Dams will modify the geomorphology of the North Fork Santiam, South Fork Santiam, and McKenzie by creating mobile gravel in-river features. The potential major increase in sediment in fine grained sediment supply form Cougar reservoir may deposit substantial fines in the South Fork McKenzie. |
| 3.4 Geology and Soils – *landslides activation* | Negligible due to deep drawdown. Small scale landslides activated at roads and rail lines during wet weather will continue. | Cottage Grove, Fern Ridge, Blue River, Dexter, Fall Creek, Big Cliff, and Foster: no to negligible due to no or small mapped landslides connected with the reservoir or no increase shoreline exposure.<br><br>Dorena, Lookout Point, and Green Peter: minor due to increase shoreline exposure and large/moderate mapped landslides that do not have a history of movement.<br><br>Cougar, Hills Creek, and Detroit: moderate due to increase shoreline exposure and large/moderate mapped | Cottage Grove, Dorena, Fern Ridge, Blue River, Dexter, Fall Creek, Big Cliff, and Foster: no to negligible due to no or small mapped landslides connected with the reservoir or no increase shoreline exposure.<br><br>Lookout Point, and Green Peter: minor due to increase shoreline exposure and large/moderate mapped landslides that do not have a history of movement.<br><br>Cougar, Hills Creek, and Detroit: moderate due to increase shoreline exposure and large/moderate mapped | Cottage Grove, Dorena, Fern Ridge, Blue River, Dexter, Fall Creek, Big Cliff, and Foster: no to negligible due to no or small mapped landslides connected with the reservoir or no increase shoreline exposure.<br><br>Lookout Point, and Green Peter: minor due to increase shoreline exposure and large/moderate mapped landslides that do not have a history of movement.<br><br>Cougar, Hills Creek, and Detroit: moderate due to increase shoreline exposure and large/moderate mapped | Cottage Grove, Fern Ridge, Blue River, Dexter, Fall Creek, Big Cliff, and Foster: no to negligible due to no or small mapped landslides connected with the reservoir or no increase shoreline exposure.<br><br>Dorena, Lookout Point, and Green Peter: minor due to increase shoreline exposure and large/moderate mapped landslides that do not have a history of movement.<br><br>Cougar, Hills Creek, and Detroit: moderate due to increase shoreline exposure and large/moderate mapped | Cottage Grove, Fern Ridge, Blue River, Dexter, Fall Creek, Big Cliff, and Foster: no to negligible due to no or small mapped landslides connected with the reservoir or no increase shoreline exposure.<br><br>Dorena, Lookout Point, and Green Peter: minor due to increase shoreline exposure and large/moderate mapped landslides that do not have a history of movement.<br><br>Cougar, Hills Creek, and Detroit: moderate due to increase shoreline exposure and large/moderate mapped | Cottage Grove, Fern Ridge, Blue River, Dexter, Fall Creek, Big Cliff, and Foster: no to negligible due to no or small mapped landslides connected with the reservoir or no increase shoreline exposure.<br><br>Dorena, Lookout Point, and Green Peter: minor due to increase shoreline exposure and large/moderate mapped landslides that do not have a history of movement.<br><br>Cougar, Hills Creek, and Detroit: moderate due to increase shoreline exposure and large/moderate mapped | Cottage Grove, Dorena, Fern Ridge, Blue River, Dexter, Fall Creek, Big Cliff, and Foster: no to negligible due to no or small mapped landslides connected with the reservoir or no increase shoreline exposure.<br><br>Lookout Point, and Green Peter: minor due to increase shoreline exposure and large/moderate mapped landslides that do not have a history of movement.<br><br>Cougar, Hills Creek, and Detroit: moderate due to increase shoreline exposure and large/moderate mapped |

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| | | landslides that do not have a history of movement. | landslides that do not have a history of movement. | landslides that do not have a history of movement. | landslides that do not have a history of movement. | landslides that do not have a history of movement. | landslides that do not have a history of movement. | landslides that do not have a history of movement. |
| 3.4 Geology and Soils - *removal of geologic materials* | No Effect | Lookout Point, Detroit, Foster, and Green Peter: minor local removal due to construction of a WTC tower and/or structural downstream passage. | Lookout Point, Detroit, Foster, and Cougar: minor local removal due to construction of a WTC tower and/or structural downstream passage. | Lookout Point, Detroit, and Foster: minor local removal due to construction of a WTC tower and/or structural downstream passage. | No Effect | No Effect | Cougar, Hills Creek, Lookout Point, Detroit, and Foster: minor local removal due to construction of a WTC tower and/or structural downstream passage. | Lookout Point, Detroit, and Foster: minor local removal due to construction of a WTC tower and/or structural downstream passage. |
| 3.5 Water Quality – *water temperature* | No to Negligible Effect | North Santiam: Negligible effect of days below 18C (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Major Benefit for Days Near Temperature Target from September through March.<br><br>South Santiam: Major Adverse effect for Days below 18 C (64.4 F) (64.4 F) (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March.<br><br>McKenzie: Negligible effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature | North Santiam: Negligible effect of days below 18C (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Major Benefit for Days Near Temperature Target from September through March.<br><br>South Santiam: Major Adverse effect for Days below 18 C (64.4 F) (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Minor Benefit for Days Near Temperature Target from September through March.<br><br>McKenzie: Negligible effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature | North Santiam: Negligible effect of days below 18C (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Major Benefit for Days Near Temperature Target from September through March.<br><br>South Santiam: Major Adverse effect for Days below 18 C (64.4 F) (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Minor Benefit for Days Near Temperature Target from September through March.<br><br>McKenzie: Negligible effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature | North Santiam: Major Adverse effect of days below 18C (Summer), Moderate Adverse effect for Days Near Temperature Target from April through August, and Minor Benefit for Days Near Temperature Target from September through March.<br><br>South Santiam: Negligible effect for Days below 18 C (64.4 F) (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Minor Benefit for Days Near Temperature Target from September through March.<br><br>McKenzie: Negligible effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Minor Adverse for Days Near Temperature | North Santiam: Negligible effect of days below 18C (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March.<br><br>South Santiam: Major Adverse effect for Days below 18 C (64.4 F) (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March.<br><br>McKenzie: Negligible effect for Days below 18 C (64.4 F) (Summer), Minor Benefit for Days Near Temperature Target from April through August, and Minor Benefit for Days Near Temperature | North Santiam: Negligible effect of days below 18C (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Major Benefit for Days Near Temperature Target from September through March.<br><br>South Santiam: Major Benefit effect for Days below 18 C (64.4 F) (Summer), Minor Benefit for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March.<br><br>McKenzie: Negligible effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature | North Santiam: Negligible effect of days below 18C (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Major Benefit for Days Near Temperature Target from September through March.<br><br>South Santiam: Major Adverse effect for Days below 18 C (64.4 F) (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Minor Benefit for Days Near Temperature Target from September through March.<br><br>McKenzie: Negligible effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature |

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| | | Target from September through March.<br><br>Middle Fork: Moderate Adverse effect for Days below 18 C (64.4 F) (Summer), Minor Benefit for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March.<br><br>Coast Fork and Long Tom: No Effect.<br><br>Mainstem Willamette: Negligible effect for Days below 18 C (64.4 F) (Summer). | Target from September through March.<br><br>Middle Fork: Negligible effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March.<br><br>Coast Fork and Long Tom: No Effect.<br><br>Mainstem Willamette: Negligible effect for Days below 18 C (64.4 F) (Summer). | Target from September through March.<br><br>Middle Fork: Negligible effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March.<br><br>Coast Fork and Long Tom: No Effect.<br><br>Mainstem Willamette: Negligible effect for Days below 18 C (64.4 F) (Summer). | Target from September through March.<br><br>Middle Fork: Major Adverse effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March.<br><br>Coast Fork and Long Tom: No Effect.<br><br>Mainstem Willamette: Minor Adverse effect for Days below 18 C (64.4 F) (Summer). | Target from September through March.<br><br>Middle Fork: Minor Adverse effect for Days below 18 C (64.4 F) (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March.<br><br>Coast Fork and Long Tom: No Effect.<br><br>Mainstem Willamette: Negligible effect for Days below 18 C (64.4 F) (Summer). | Target from September through March.<br><br>Middle Fork: Major Adverse effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March.<br><br>Coast Fork and Long Tom: No Effect.<br><br>Mainstem Willamette: Minor Adverse effect for Days below 18 C (64.4 F) (Summer). | Target from September through March.<br><br>Middle Fork: Negligible effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March.<br><br>Coast Fork and Long Tom: No Effect.<br><br>Mainstem Willamette: Negligible effect for Days below 18 C (64.4 F) (Summer). |
| 3.5 Water Quality – *Total Dissolved Gas* | No to Negligible Effect | North Santiam: Moderate Benefit from TDG improvements.<br><br>South Santiam and Middle Fork: Negligible Effect.<br><br>McKenzie: Minor Benefit from TDG improvements<br><br>Middle Fork: Negligible Effect.<br><br>Coast Fork and Long Tom: Negligible Effect. | North Santiam: Moderate Benefit from TDG improvements.<br><br>South Santiam: Major Adverse effect is observed at Green Peter Reservoir and Moderate Adverse effect is observed at Foster Reservoir.<br><br>McKenzie and Middle Fork Subbasins: Negligible Effect.<br><br>Coast Fork and Long Tom: No Effect. | North Santiam: Moderate Benefit from TDG improvements.<br><br>South Santiam: Major Adverse effect is observed at Green Peter Reservoir and Moderate Adverse effect is observed at Foster Reservoir.<br><br>McKenzie: Minor Beneficial improvements of TDG.<br><br>Middle Fork: Negligible Effect.<br><br>Coast Fork and Long Tom: No Effect | North Santiam: Moderate Benefit from TDG improvements.<br><br>South Santiam: Major Adverse effect is observed at Green Peter Reservoir, Moderate Adverse effect is observed at Foster Reservoir, and Minor Adverse effect would be observed at Dexter Reservoir.<br><br>McKenzie and Middle Fork Subbasins: Negligible Effect.<br><br>Coast Fork and Long Tom: No Effect | North Santiam: Moderate Adverse effect.<br><br>South Santiam: Minor Adverse effect.<br><br>McKenzie: Minor Beneficial improvements of TDG.<br><br>Middle Fork: Negligible Effect.<br><br>Coast Fork and Long Tom: No Effect | North Santiam: Moderate Benefit from TDG improvements.<br><br>South Santiam: Major Adverse effect.<br><br>McKenzie: Minor Beneficial improvements of TDG.<br><br>Middle Fork: Negligible Effect.<br><br>Coast Fork and Long Tom: No Effect | North Santiam: Moderate Benefit from TDG improvements.<br><br>South Santiam: Major Adverse effect is observed at Green Peter Reservoir and Moderate Adverse effect is observed at Foster Reservoir.<br><br>McKenzie: Minor Beneficial improvements of TDG.<br><br>Middle Fork: Negligible Effect.<br><br>Coast Fork and Long Tom: No Effect |

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| 3.6 Vegetation (including ESA/sensitive species and critical habitat) –*riverine vegetative communities downstream of WVS dams* | Negligible Effect<br><br>The hydrologic regime and associated vegetation would continue similar to existing conditions. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>Mainstem Willamette River and Long Tom: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>South Santiam: Minor short-term effects (sediment) from deep annual drawdown at Green Peter.<br><br>Mainstem Willamette River, Coast Fork, and Long Tom: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>South Santiam and South Fork McKenzie: Minor short-term effects (sediment) from deep annual drawdowns at Green Peter and Cougar.<br><br>Mainstem Willamette River, Coast Fork, and Long Tom: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Minor short-term effects (sediment) from deep annual drawdowns at Detroit, Green Peter, Cougar, Blue River, Lookout Point, and Hills Creek.<br><br>Mainstem Willamette River, Coast Fork, and Long Tom: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>Detroit, Green Peter, Cougar, Blue River, Lookout Point, and Hills Creek: Deep annual drawdown(s) with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream reaches.<br><br>Mainstem Willamette River, Coast Fork, and Long Tom: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>Mainstem Willamette River and Long Tom: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>South Santiam and South Fork McKenzie: Minor short-term effects (sediment) from deep annual drawdowns at Green Peter and Cougar.<br><br>Mainstem Willamette River, Coast Fork, and Long Tom: Negligible effect. |
| 3.6 Vegetation (including ESA/sensitive species and critical habitat) – *vegetative communities around the reservoirs* | Negligible Effect<br><br>The hydrologic regime and associated vegetation would continue similar to existing conditions. | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, Fall Creek, Cottage Grove, and Dorena: Minor hydrological effects and minor adverse localized effects from slope failures. | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, and Fall Creek: Minor hydrological effects and minor adverse localized effects from slope failures.<br><br>Green Peter: Long-term moderate effects of deep annual drawdown. | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, and Fall Creek: Minor hydrological effects and minor adverse localized effects from slope failures.<br><br>Green Peter and Cougar: Long-term moderate effects of deep annual drawdowns. | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, and Fall Creek: Minor hydrological effects and minor adverse localized effects from slope failures.<br><br>Detroit, Green Peter, Cougar, Blue River, Lookout Point, and Hills Creek: Long-term moderate effects of deep annual drawdowns. | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, Fall Creek, Cottage Grove, and Dorena: Minor hydrological effects and minor adverse localized effects from slope failures.<br><br>Detroit, Green Peter, Cougar, Blue River, Lookout Point, and Hills Creek: Long-term moderate effects of deep annual drawdowns. | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, Fall Creek, Cottage Grove, and Dorena: Minor hydrological effects and minor adverse localized effects from slope failures. | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, and Fall Creek: Minor hydrological effects and minor adverse localized effects from slope failures.<br><br>Green Peter and Cougar: Long-term moderate effects of deep annual drawdowns. |

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| | | | | | Blue River: Minor hydrological effects of drawdown. | Blue River: Minor hydrological effects of drawdown. | | |
| 3.7 Wetlands – *streamside wetlands downstream of WVS dams* | Negligible Effect<br><br>The hydrologic regime and associated wetlands would continue similar to existing conditions. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>Mainstem Willamette River and Long Tom: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>South Santiam: Minor short-term effects (sediment) from deep annual drawdown at Green Peter.<br><br>Mainstem Willamette River, Coast Fork, and Long Tom: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>South Santiam and South Fork McKenzie: Minor short-term effects (sediment) from deep annual drawdowns at Green Peter and Cougar.<br><br>Mainstem Willamette River, Coast Fork, and Long Tom: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Minor short-term effects (sediment) from deep annual drawdowns at Detroit, Green Peter, Cougar, Blue River, Lookout Point, and Hills Creek.<br><br>Mainstem Willamette River, Coast Fork, and Long Tom: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>Detroit, Green Peter, Cougar, Blue River, Lookout Point, and Hills Creek: Deep annual drawdown(s) with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream reaches.<br><br>Mainstem Willamette River, Coast Fork, and Long Tom: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>Mainstem Willamette River and Long Tom: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>South Santiam and South Fork McKenzie: Minor short-term effects (sediment) from deep annual drawdowns at Green Peter and Cougar.<br><br>Mainstem Willamette River, Coast Fork, and Long Tom: Negligible effect. |
| 3.7 Wetlands – *wetlands around the reservoirs* | Negligible Effect<br><br>The hydrologic regime and associated wetlands would continue similar to existing conditions. | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, Fall Creek, Cottage Grove, and Dorena: Minor hydrological effects and minor adverse localized effects from slope failures. | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, and Fall Creek: Minor hydrological effects and minor adverse localized effects from slope failures.<br><br>Green Peter: Long-term moderate effects of deep annual drawdown. | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, and Fall Creek: Minor hydrological effects and minor adverse localized effects from slope failures.<br><br>Green Peter and Cougar: Long-term moderate effects of deep annual drawdowns. | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, and Fall Creek: Minor hydrological effects and minor adverse localized effects from slope failures.<br><br>Detroit, Green Peter, Cougar, Blue River, Lookout Point, and Hills Creek: Long-term moderate effects of | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, Fall Creek, Cottage Grove, and Dorena: Minor hydrological effects and minor adverse localized effects from slope failures.<br><br>Detroit, Green Peter, Cougar, Blue River, Lookout Point, and Hills Creek: Long-term | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, Fall Creek, Cottage Grove, and Dorena: Minor hydrological effects and minor adverse localized effects from slope failures. | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, and Fall Creek: Minor hydrological effects and minor adverse localized effects from slope failures.<br><br>Green Peter and Cougar: Long-term moderate effects of deep annual drawdowns. |

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| | | | | | deep annual drawdowns.<br><br>Blue River: Minor hydrological effects of drawdown. | moderate effects of deep annual drawdowns.<br><br>Blue River: Minor hydrological effects of drawdown. | | |
| 3.8 Fish, Aquatic Invertebrates, and Aquatic Habitat (including ESA/sensitive species and critical habitat) – Chinook | Major adverse effects on Chinook salmon. Life cycle models predict high extinction risk for in all sub-basins.<br><br>Climate change is predicted will reduce the ability to meet operational fish passage, minimum flows, and water temperature objectives below dams for Chinook. | North and South Santiam: Major effects on Chinook salmon. Lifecycle models predict low extinction risk for Chinook.<br><br>McKenzie and Middle Fork: Lifecycle models predict high risk of extinction. The downstream passage structure at Lookout Point is dependent on the dam operations and predicted to perform poorly likely due to the storage theme of Alternative 1.<br><br>Structural improvements for fish passage and water temperature provide resilience to climate change by increasing operational flexibility in the North Santiam, South Santiam, McKenzie and Middle Fork sub-basins. | Moderate adverse effects on Chinook salmon, predicted to produce the most viable populations compared to other alternatives.<br><br>McKenzie: Retains the core legacy population.<br><br>South Santiam: The IPA predicts low extinction risk with a viable population above Foster, whereas the LCM does not.<br><br>Santiam:<br>Middle Fork: produces the most optimistic outcomes for Chinook salmon among the alternatives, accomplished with a downstream passage structure at Lookout Point exclusive of passage at Hills Creek. Structural improvements for fish passage and water temperature provide resilience to climate change by increasing operational flexibility in the North Santiam, South Santiam, Middle Fork sub-basins. | Moderate adverse effects on Chinook salmon, predicted to produce the most viable populations compared to other alternatives.<br><br>McKenzie: Retains the core legacy population. Increased adverse effects to Chinook compared to Alternative 2A (still moderate).<br><br>South Santiam: The IPA predicts low extinction risk with a viable population above Foster, whereas the LCM does not.<br><br>Santiam:<br>Middle Fork: produces the most optimistic outcomes for Chinook salmon among the alternatives, accomplished with a downstream passage structure at Lookout Point exclusive of passage at Hills Creek.<br><br>Structural improvements for fish passage and water temperature provide resilience to climate change by | Major adverse effects for Chinook. Predicted performance for this species is very similar to the NAA.<br><br>North Santiam: some improvement over NAA.<br><br>Climate change will reduce the ability to meet operational fish passage, minimum flows, and water temperature targets below dams for Chinook. | Moderate to Major adverse effects for Chinook.<br><br>North Santiam and McKenzie: Performance for Chinook is predicted as viable to nearly viable.<br><br>Climate change will reduce the ability to meet operational fish passage, minimum flows, and water temperature targets below dams for Chinook. | Moderate adverse for Chinook salmon.<br><br>North and South Santiam and McKenzie: Life cycle models predicts low extinction risk for Chinook.<br><br>Middle Fork: Only one model predicts low extinction risk.<br><br>Structures for fish passage and temperatures will increase resiliency to climate change by improving operational flexibility. | Moderate adverse effects on Chinook salmon, predicted to produce the most viable populations compared to other alternatives.<br><br>McKenzie: Retains the core legacy population. Increased adverse effects to Chinook compared to Alternative 2A (still moderate).<br><br>South Santiam: The IPA predicts low extinction risk with a viable population above Foster, whereas the LCM does not.<br><br>Santiam:<br>Middle Fork: produces the most optimistic outcomes for Chinook salmon among the alternatives, accomplished with a downstream passage structure at Lookout Point exclusive of passage at Hills Creek.<br><br>Structural improvements for fish passage and water temperature provide resilience to climate change by |

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| | | | | increasing operational flexibility in the North Santiam, South Santiam, and Middle Fork sub-basins. | | | | increasing operational flexibility in the North Santiam, South Santiam, and Middle Fork sub-basins. |
| 3.8 Fish, Aquatic Invertebrates, and Aquatic Habitat (including ESA/sensitive species and critical habitat) – *winter steelhead* | MAJOR adverse effects on winter steelhead. Life cycle models predict high extinction risk for in all sub-basins.<br>Climate change is predicted will reduce the ability to meet operational fish passage, minimum flows, and water temperature objectives below dams for steelhead | North and South Santiam: MINOR adverse effects on winter steelhead. Both life cycle models predict low extinction risk in Santiam winter steelhead populations, although one model predicted low recruits per spawning for the South Santiam. | North and South Santiam: MINOR adverse effects to Santiam winter steelhead populations, with good performance in all metric dimensions in both life cycle models except for the South Santiam under the LCM. | North and South Santiam: MINOR adverse effects to Santiam winter steelhead populations, with good performance in all metric dimensions in both life cycle models except for the South Santiam under the LCM. | Major adverse effects for steelhead. Predicted performance for this species is very similar to the NAA.<br><br>South Santiam: some improvement over NAA.<br><br>Climate change will reduce the ability to meet operational fish passage, minimum flows, and water temperature targets below dams for steelhead. | Moderate to Major adverse effects for steelhead.<br><br>North and South Santiam: Performance for steelhead is predicted as viable to nearly viable.<br><br>Climate change will reduce the ability to meet operational fish passage, minimum flows, and water temperature targets below dams for steelhead. | Minor adverse effects for winter steelhead.<br><br>North Santiam: Life cycle models predict low extinction risk for steelhead.<br><br>South Santiam: only model predicts low extinction risk for steelhead. | North and South Santiam: MINOR adverse effects to Santiam winter steelhead populations, with good performance in all metric dimensions in both life cycle models except for the South Santiam under the LCM. |
| 3.8 Fish, Aquatic Invertebrates, and Aquatic Habitat (including ESA/sensitive species and critical habitat) – *bull trout* | Minor adverse effects for bull trout. Bull trout above Cougar have been stable for several years and have been increasing above Hills Creek. Habitat scores for bull trout are reasonable, with 100% of the available spawning habitat available, and 70% of the rearing habitat available. Passage conditions at dams limit bull trout access to below dam rearing habitat.<br><br>Climate change is predicted to further degrade habitat for bull trout below dams | Minor adverse effects for bull trout. The EDT output indicates that Alternative 1 is somewhat resilient to different hydrology year types with respect to life history diversity. Scores and risks for bull trout would be ranked similar to the NAA with MINOR effects<br>predicted. Habitat scoring for bull trout is only marginally better than in the NAA with rearing habitat increases for North Santiam bull trout below Detroit. | Minor adverse effects for bull trout. EDT results shows resiliency with respect to recruits per spawner. Bull trout habitat scores and risks are comparable to Alternative 1, with a fish passage addition providing access to habitat below Cougar Dam. | Minor adverse effects for bull trout. EDT results shows resiliency with respect to recruits per spawner. Bull trout habitat scores and risks are comparable to Alternative 1, with a fish passage addition providing access to habitat below Cougar Dam.<br><br>McKenzie: increased adverse effects to bull trout compared to Alternative 2A (still moderate) | Major adverse effects for Bull trout. Reservoir rearing area is significantly reduced in both Detroit and Cougar reservoirs and expected to result in increased movement into more degraded rearing habitat below Detroit and Hills Creek dams where spawning habitat does not exist, and human disturbance is high.<br><br>Climate change is predicted to further degrade habitat for bull trout below dams. | Moderate to Major adverse effects for bull trout. Reservoir rearing area is significantly reduced in Cougar Reservoir, and passage will result in increased movement into more degraded rearing habitat below Detroit and Hills Creek dams where spawning habitat does not exist, and human disturbance is high.<br><br>Climate change is predicted to further degrade habitat for bull trout below dams. | Moderate adverse effects for bull trout. The EDT output also indicates Alternative 4 is somewhat resilient to different hydrology year types with respect to life history diversity. Habitat scoring for bull trout is improved in all three sub-basins due to passage actions, however access to below dam habitat increases demographic risks especially below Hills Creek and secondarily below Detroit where spawning habitat does not exist, and human disturbance is high. | Minor adverse effects for bull trout. EDT results shows resiliency with respect to recruits per spawner. Bull trout habitat scores and risks are comparable to Alternative 1, with a fish passage addition providing access to habitat below Cougar Dam.<br><br>McKenzie: increased adverse effects to bull trout compared to Alternative 2A (still moderate) |

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| | | | | | | | Climate change is predicted to further degrade habitat for bull trout below dams. | |
| 3.9 Wildlife, Birds, and Terrestrial Habitat (including ESA/sensitive species and critical habitat) –*aquatic and wetland habitat downstream of WVS dams* | The hydrologic regime and associated wildlife habitat would continue similar to existing conditions. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>North and South Santiam, Long Tom, and Middle Fork: Minor long-term benefits from increased fish populations to habitat functions related to nutrient cycling because of fish decaying in these sub-basins after spawning.<br><br>North and South Santiam, McKenzie, and Middle Fork: Minor benefits for foraging wildlife from water quality improvements.<br><br>Mainstem Willamette River: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>North and South Santiam, McKenzie, and Middle Fork: Minor long-term benefits from increased fish populations to habitat functions related to nutrient cycling because of fish decaying in these sub-basins after spawning.<br><br>North and South Santiam: Minor benefits for foraging wildlife from water quality improvements.<br><br>Mainstem Willamette River, Coast Fork, and Long Tom: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>North and South Santiam, McKenzie, and Middle Fork: Minor long-term benefits from increased fish populations to habitat functions related to nutrient cycling because of fish decaying in these sub-basins after spawning.<br><br>North and South Santiam: Minor benefits for foraging wildlife from water quality improvements.<br><br>Mainstem Willamette River, Coast Fork, and Long Tom: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>North and South Santiam, McKenzie, and Middle Fork: Minor long-term benefits from increased fish populations to habitat functions related to nutrient cycling because of fish decaying in these sub-basins after spawning.<br><br>North and South Santiam, Blue River, and Middle Fork: Minor benefits for foraging wildlife from water quality improvements.<br><br>Mainstem Willamette River, Coast Fork, and Long Tom: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>North and South Santiam, McKenzie, and Middle Fork: Minor long-term benefits from increased fish populations to habitat functions related to nutrient cycling because of fish decaying in these sub-basins after spawning.<br><br>North and South Santiam, Blue River, and Middle Fork: Minor benefits for foraging wildlife from water quality improvements.<br><br>Mainstem Willamette River, Coast Fork, and Long Tom: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>North and South Santiam, Long Tom, and Middle Fork: Minor long-term benefits from increased fish populations to habitat functions related to nutrient cycling because of fish decaying in these sub-basins after spawning.<br><br>North and South Santiam, South Fork McKenzie, and Middle Fork: Minor benefits for foraging wildlife from water quality improvements.<br><br>Mainstem Willamette River and Long Tom: Negligible effect. | North and South Santiam, South Fork McKenzie, Blue River, and Middle Fork: Long-term benefits from downstream gravel augmentation and negligible hydrological effects from minor decreases to downstream flows.<br><br>North and South Santiam, McKenzie, and Middle Fork: Minor long-term benefits from increased fish populations to habitat functions related to nutrient cycling because of fish decaying in these sub-basins after spawning.<br><br>North and South Santiam: Minor benefits for foraging wildlife from water quality improvements.<br><br>Mainstem Willamette River, Coast Fork, and Long Tom: Negligible effect. |
| 3.9 Wildlife, Birds, and Terrestrial Habitat (including ESA/sensitive species and critical habitat) –*aquatic and wetland* | The hydrologic regime and associated wildlife habitat would continue similar to existing conditions. | Detroit, Green Peter, Foster, Cougar, Lookout Point, Hills Creek, Fall Creek, Cottage Grove, and Dorena: Minor long-term adverse effects to wildlife access to the | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, and Fall Creek: Minor long-term adverse effects to wildlife access to the | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, and Fall Creek: Minor long-term adverse effects to wildlife access to the | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, and Fall Creek: Minor long-term adverse effects to wildlife access to the | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, and Fall Creek: Minor long-term adverse effects to wildlife access to the | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, Fall Creek, Cottage Grove, and Dorena: Minor long-term adverse effects to wildlife access to the | Detroit, Green Peter, Cougar, Lookout Point, Hills Creek, and Fall Creek: Minor long-term adverse effects to wildlife access to the |

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| *habitat around reservoirs* | | water's edge during the late summer and fall. | water's edge during the late summer and fall.<br>Green Peter: Long-term moderate adverse effects of deep annual drawdowns due to minor to moderate long-term adverse effects to wetland wildlife habitat as well as to effecting wildlife access, primarily mammalian species, to the water's edge.<br><br>Cottage Grove and Dorena: Negligible effect. | water's edge during the late summer and fall.<br>Green Peter and Cougar: Long-term moderate adverse effects of deep annual drawdowns due to minor to moderate long-term adverse effects to wetland wildlife habitat as well as to effecting wildlife access, primarily mammalian species, to the water's edge.<br><br>Cottage Grove and Dorena: Negligible effect. | water's edge during the late summer and fall.<br>Detroit, Green Peter, Cougar, Blue River, Lookout Point, and Hills Creek: Long-term moderate adverse effects of deep annual drawdowns due to minor to moderate long-term adverse effects to wetland wildlife habitat as well as to wildlife access, primarily mammalian species, to the water's edge and potentially damaging wildlife habitat structures through water level fluctuations, and potentially impacting northwestern pond turtle nesting.<br><br>Blue River: Minor hydrological effects of drawdown.<br><br>Cottage Grove and Dorena: Negligible effect. | water's edge during the late summer and fall.<br>Detroit, Green Peter, Cougar, Blue River, Lookout Point, and Hills Creek: Long-term moderate adverse effects of deep annual drawdowns due to minor to moderate long-term adverse effects to wetland wildlife habitat as well as to wildlife access, primarily mammalian species, to the water's edge and potentially damaging wildlife habitat structures through water level fluctuations, and potentially impacting northwestern pond turtle nesting.<br><br>Blue River: Minor hydrological effects of drawdown.<br><br>Cottage Grove and Dorena: Negligible effect. | water's edge during the late summer and fall.<br><br>Cottage Grove and Dorena: Negligible effect. | water's edge during the late summer and fall.<br>Green Peter and Cougar: Long-term moderate adverse effects of deep annual drawdowns due to minor to moderate long-term adverse effects to wetland wildlife habitat as well as to effecting wildlife access, primarily mammalian species, to the water's edge.<br><br>Cottage Grove and Dorena: Negligible effect. |
| 3.9 Wildlife, Birds, and Terrestrial Habitat (including ESA/sensitive species and critical habitat) – *piscivorous (fish eating) wildlife species* | North Santiam, South Santiam, McKenzie, and Middle Fork: Long-term, minor, adverse effect to piscivorous wildlife species and overall habitat function due to limited foraging opportunities within stream reaches upstream of the WVS dams where passage has not been provided for native migratory fish, | North and South Santiam, McKenzie, Long Tom, and Middle Fork: Long-term minor benefits from fish passage | North and South Santiam, McKenzie, and Middle Fork: Long-term minor benefits from fish passage. | North and South Santiam, McKenzie, and Middle Fork: Long-term minor benefits from fish passage. | North and South Santiam, McKenzie, and Middle Fork: Long-term minor benefits from fish passage. | North and South Santiam, McKenzie, and Middle Fork: Long-term minor benefits from fish passage. | North and South Santiam, McKenzie, Long Tom, and Middle Fork: Long-term minor benefits from fish passage | North and South Santiam, McKenzie, and Middle Fork: Long-term minor benefits from fish passage. |

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| | including salmonids and Pacific lamprey. | | | | | | | |
| 3.10 Air Quality | The effects would be negligible in magnitude, short term and long term in duration, and small and large in extent. The effects would be primarily due to emissions associated with fish trucking mileage and generator usage, in addition to fugitive dust associated with the Fall Creek reservoir drawdown. | Short- and long-term effects would be minor in magnitude and small in extent. These effects would be primarily due to the construction equipment used for this structural measure and the reduction in emissions associated with the measure. Negligible to minor effects in the medium and long term would be small and large in extend. These effects would be primarily due to emissions associated with construction, fish trucking mileage, and generator usage. | Negligible to minor effects in the medium and long term would be small and large in extend. These effects would be primarily due to emissions associated with construction, fish trucking mileage, and generator usage. Negligible effects in the short term and long term would be small in extent. These effects would be primarily due to fugitive dust associated with reservoir drawdowns. | Negligible to minor effects in the medium and long term would be small and large in extend. These effects would be primarily due to emissions associated with construction, fish trucking mileage, and generator usage. Negligible effects in the short term and long term would be small in extent. These effects would be primarily due to fugitive dust associated with reservoir drawdowns. | Negligible to minor effects in the medium and long term would be small and large in extend. These effects would be primarily due to emissions associated with construction, fish trucking mileage, and generator usage. Negligible effects in the short term and long term would be small in extent. These effects would be primarily due to fugitive dust associated with reservoir drawdowns. | Negligible to minor effects in the medium and long term would be small and large in extend. These effects would be primarily due to emissions associated with construction, fish trucking mileage, and generator usage. Negligible effects in the short term and long term would be small in extent. These effects would be primarily due to fugitive dust associated with reservoir drawdowns. | Short- and long-term effects would be minor in magnitude and small in extent. These effects would be primarily due to the construction equipment used for this structural measure and the reduction in emissions associated with the measure. Negligible to minor effects in the medium and long term would be small and large in extend. These effects would be primarily due to emissions associated with construction, fish trucking mileage, and generator usage. | Negligible to minor effects in the medium and long term would be small and large in extend. These effects would be primarily due to emissions associated with construction, fish trucking mileage, and generator usage. Negligible effects in the short term and long term would be small in extent. These effects would be primarily due to fugitive dust associated with reservoir drawdowns. |
| 3.11 Socioeconomics | The effects would be negligible to major magnitude, short-term or long-term duration, and localized to statewide in extent. Long-term, major effects would be primarily due to extirpation of wild UWR Chinook salmon and UWR steelhead and the loss of their corresponding existence values to communities throughout the state. Other long-term effects from the recurring Fall Creek drawdown would be minor and localized. | The effects would be minor to moderate magnitude, short-term to long-term duration, and localized to statewide in extent. The effects of minor magnitude would be beneficial and would result from the provision of recurring additional water supply to agricultural and municipal and industrial users throughout the WVS. Adverse long-term effects of minor to moderate magnitude would also occur due to visual disturbances resulting from the erection of new structures. | The effects would be negligible to minor magnitude, short-term to long-term duration, and localized to statewide in extent. The effects of minor magnitude would be primarily due to reduction of recreational value of reservoirs for residents and visitors during construction phases and reduction of water supply for municipal and industrial users throughout the WVS. Long term effects from reduction of water supply and visual disturbance of new structures would be of minor magnitude. | The effects would be negligible to minor magnitude, short-term to long-term duration, and localized to statewide in extent. The effects of minor magnitude would be primarily due to reduction of recreational value of reservoirs for residents and visitors during construction phases and reduction of water supply for agricultural and municipal and industrial users throughout the WVS. Long-term effects from reduction of water supply and visual disturbance of new | The effects would be negligible to major magnitude, short-term to long-term duration, and localized to statewide in extent. The effects of major magnitude would be primarily due to the reduction of water supply for agricultural and municipal and industrial users throughout the WVS. Long-term effects from reduction of water supply would be major in magnitude and long-term effects of visual disturbance of new structures would be of minor magnitude. | The effects would be negligible to major magnitude, short-term to long-term duration, and localized to statewide in extent. The effects of major magnitude would be primarily due to the reduction of water supply for agricultural and municipal and industrial users throughout the WVS. Long-term effects from reduction of water supply would be major in magnitude and long-term effects of visual disturbance of new structures would be of minor magnitude. | The effects would be minor to moderate magnitude, short-term to long-term duration, and localized to statewide in extent. The effects of moderate magnitude would be primarily due to the reduction of recreational value of reservoirs for residents and visitors during construction phases. Long term effects of visual disturbances of new structures would be of minor magnitude. | The effects would be negligible to minor magnitude, short-term to long-term duration, and localized to statewide in extent. The effects of minor magnitude would be primarily due to reduction of recreational value of reservoirs for residents and visitors during construction phases and reduction of water supply for municipal and industrial users throughout the WVS. Long term effects from reduction of water supply and visual disturbance of new structures would be of minor magnitude. |

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| | | | | structures would be of minor magnitude. | | | | |
| 3.12 Power and Transmission - *Regional Power System Reliability Effects* | No/Negligible Effect. WVS Projects 73-Year Average Generation is estimated to be 171 aMW (roughly the amount of power used by 136,416 Northwest homes or used by residential customers in a city slightly more populated than Gresham, Oregon). Loss of Load Probability (LOLP) is 6.5%, which is within the range of the Pacific Northwest Power System LOLP in recent years, and the risk of blackouts or power shortages is about once every 15 years. | Negligible impact on power system reliability. Average annual hydropower generation from the WVS projects would increase by 8 aMW (roughly enough to power 6,371 households annually). LOLP only decreases by 0.1 percent and the risk of blackouts or power shortages remains the same resulting in no detectable change to regional power system reliability. | Negligible impact on power system reliability. Average annual hydropower generation from the WVS projects would decrease by 4 aMW (roughly enough to power 3,185 households annually). LOLP and the risk of blackouts or power shortages remain the same as the NAA. | Negligible impact on power system reliability. Average annual hydropower generation from the WVS projects would decrease by 18 aMW (roughly enough to power 14,334 households annually). LOLP only increases by 0.1 percent and the risk of blackouts or power shortages remains the same resulting in no detectable change to regional power system reliability. | Negligible Impact on power system reliability. Hydropower generation from the WVS projects would decrease by 87 aMW (roughly enough to power 69,283 households annually). LOLP only increases by 0.5 percent and the risk of blackouts or power shortages remains the same resulting in no detectable change to regional power system reliability. | Negligible Impact on power system reliability. Hydropower generation from the WVS projects would decrease by 79 aMW (roughly enough to power 62,912 households annually). LOLP only decreases by 0.5 percent and the risk of blackouts or power shortages remains the same resulting in no detectable change to regional power system reliability. | Negligible impact on power system reliability. Average annual hydropower generation from the WVS projects would increase by 1 aMW (roughly enough to power 796 households annually). LOLP and the risk of blackouts or power shortages remain the same. | Negligible impact on power system reliability. Average annual hydropower generation from the WVS projects would decrease by 18 aMW (roughly enough to power 14,334 households annually). LOLP only increases by 0.1 percent and the risk of blackouts or power shortages remains the same resulting in no detectable change to regional power system reliability. |
| 3.12 Power and Transmission - *Transmission System Effects* | No/Negligible Effect. The congested paths of Cross Cascades South (CCS) and South of Allston (SOA) remain congested. Generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages due to, especially, weather events or fires. | Long-term, minor, adverse effects on the transmission system. Less than 10MW increased loading on congested paths all seasons (CCS and SOA). Generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated) similar to the NAA. Construction projects at Cougar Dam are not anticipated to impact local transmission services to Blue River provided generation is not affected. | Long-term, moderate, adverse effects on the transmission system. Increased loading in winter on CCS path (18.4MW) and in spring on both CCS (61.3MW) and SOA (11.8MW) paths. Generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated), providing transmission services to Oakridge and Blue River, respectively, similar to the NAA. Construction projects at Cougar Dam are not anticipated to impact local transmission services to Blue River provided | Long-term, moderate, adverse effects on the transmission system. Increased loading in winter on CCS path (21.9MW) and in spring on both CCS (25.1MW) and SOA (5.1MW) paths. Generation at Hills Creek Dam would remain able to operate islanded (isolated), providing transmission services to Oakridge, similar to the NAA. Infrequent, temporary major adverse effects on transmission services to Blue River. Deep fall and spring drawdowns would compromise Cougar Dam's ability to operate islanded and | Long-term, moderate, adverse effects on the transmission system. Increased loading on CCS and SOA paths in winter (37.2MW and 13.6MW, respectively) and spring (113.7 MW and 22.3 MW, respectively). Infrequent, temporary major adverse effects on transmission services to Oakridge and Blue River. Deep fall and spring drawdowns would compromise the Hills Creek and Cougar dams' respective abilities to operate islanded and serve these communities under temporary storm or fire related outage conditions. | Long-term, moderate, adverse effects on the transmission system. Increased loading on CCS path all seasons (winter: 41.4MW, spring: 94.8 MW, and summer: 25.6MW) and on SOA path in winter (15.2MW) and spring (18.7 MW). Infrequent, temporary major adverse effects on transmission services to Oakridge and Blue River. Deep fall and spring drawdowns would compromise the Hills Creek and Cougar dams' respective abilities to operate islanded and serve these communities under temporary | Long-term, minor, adverse effects on the transmission system. Less than 10MW increased loading on congested paths (CCS and SOA) all seasons with exception of a slightly greater increase on the CCS path in spring (15MW). Generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated) similar to the NAA. Construction projects at Hills Creek and Cougar dams are not anticipated to impact local transmission services to Oakridge and Blue River, respectively, provided | Long-term, moderate, adverse effects on the transmission system. Increased loading in winter on CCS path (21.9MW) and in spring on both CCS (25.1MW) and SOA (5.1MW) paths. Generation at Hills Creek Dam would remain able to operate islanded (isolated), providing transmission services to Oakridge, similar to the NAA. Infrequent, temporary major adverse effects on transmission services to Blue River. Deep fall and spring drawdowns would compromise Cougar Dam's ability to operate islanded and |

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| | | | generation is not affected. | serve this community under temporary weather or fire related outage conditions. | | weather or fire related outage conditions. | generation is not affected. | serve this community under temporary weather or fire related outage conditions. |
| 3.12 Power and Transmission - *Economic Viability of Power Generation Effects* | No/Negligible Effect. Power generation for combined WVS projects would continue to be marginally economically viable. Net Present Value (NPV) for the combined WVS is about $225 million and the median Levelized Cost of Generation is estimated to be $26.70/MWh. | Long-term, major, adverse effects on economic viability of power generation. There would be a $1.159 billion reduction in NPV to -$993 million and a $27.14 increase in the Levelized Cost of Generation to $53.84/MWh. | Long-term, major, adverse effects on economic viability of power generation. There would be a $863 million reduction in NPV to -$638 million and a $20.75 increase in the Levelized Cost of Generation to $47.45/MWh. | Long-term, major, adverse effects on economic viability of power generation. There would be a $933 million reduction in NPV to -$708 million and a $23.96 increase in the Levelized Cost of Generation to $50.66/MWh. | Long-term, major, adverse effects on economic viability of power generation. There would be a $853 million reduction in NPV to -$628 million and a $37.61 increase in the Levelized Cost of Generation to $64.32/MWh. | Long-term, major, adverse effects on economic viability of power generation. There would be a $829 million reduction in NPV to -$604 million and a $32.72 increase in the Levelized Cost of Generation to $59.42/MWh. | Long-term, major, adverse effects on economic viability of power generation. There would be a $1.162 billion reduction in NPV to -$937 million and a $27.84 increase in the Levelized Cost of Generation to $54.54/MWh. | Long-term, major, adverse effects on economic viability of power generation. There would be a $939 million reduction in Net Present Value to -$714 million and a $24.11 increase in the Levelized Cost of Generation to $50.81/MWh. |
| 3.13 Water Supply (Irrigation, Municipal, and Industrial) | Same or similar to affected environment for existing live flow water rights.<br><br>Moderate beneficial effects to M&I storage agreements.<br><br>Maintains hydrology of WRB consistent with existing conditions, with the addition of increased releases for M&I water storage agreements. | Negligible to minor beneficial effect to live flow water rights basin wide. Minor adverse effects to live flow water rights in the North Santiam sub-basin.<br><br>Moderate beneficial effect to M&I and irrigation users relying on stored water. | Negligible effect to live flow water rights basin wide. Minor adverse effects to live flow water rights in the North Santiam sub-basin.<br><br>Minor beneficial effect to M&I and irrigation users relying on stored water. | Minor beneficial effect to live flow water rights basin wide. Minor adverse effects to live flow water rights in the North Santiam sub-basin.<br><br>Minor adverse effect to M&I and irrigation users relying on stored water. | Negligible to moderate adverse effects to live flow water rights. Major adverse effects in the North Santiam due to spring drawdown of Detroit Reservoir.<br><br>Major adverse effect to M&I and irrigation users relying on stored water. | Minor to major adverse effects to live flow water rights.<br><br>Major adverse effect to M&I and irrigation users relying on stored water. | Negligible effect basin wide; minor adverse in the North Santiam.<br><br>Minor beneficial effect to M&I and irrigation users relying on stored water. | Negligible effect to live flow water rights basin wide; minor adverse in the North Santiam.<br><br>Minor adverse effect to M&I and irrigation users relying on stored water. |
| 3.14 Recreation | Effects would be adverse, negligible to moderate in magnitude, and local in extent in the short-, medium-, and long- term due to scheduled/routine maintenance and major maintenance and rehabilitation. Major, local, adverse effects would occur in the short term and recur in the long term due to drawdowns. | Effects would be adverse, negligible to moderate in magnitude, and local in extent in the short-, medium-, and long- term due to scheduled/routine maintenance, major maintenance and rehabilitation, and structural measures. Major, local, adverse effects would occur in the short term and recur in the long term due to | Effects would be adverse, negligible to moderate in magnitude, and local in extent in the short-, medium-, and long- term due to scheduled/routine maintenance, major maintenance and rehabilitation, and structural measures. Major, local, adverse effects would occur in the short term and recur in the long term due to | Effects would be adverse, negligible to moderate in magnitude, and local in extent in the short-, medium-, and long- term due to scheduled/routine maintenance, major maintenance and rehabilitation, and structural measures. Major, local, adverse effects would occur in the short term and recur in the long term due to | Effects would be adverse, negligible to moderate in magnitude, and local in extent in the short-, medium-, and long- term due to scheduled/routine maintenance, major maintenance and rehabilitation, and structural measures. Major, local, adverse effects would occur in the short term and recur in the long term due to | Effects would be adverse, negligible to moderate in magnitude, and local in extent in the short-, medium-, and long- term due to scheduled/routine maintenance, major maintenance and rehabilitation, and structural measures. Major, local, adverse effects would occur in the short term and recur in the long term due to | Effects would be adverse, negligible to moderate in magnitude, and local in extent in the short-, medium-, and long- term due to scheduled/routine maintenance, major maintenance and rehabilitation, and structural measures. Major, local, adverse effects would occur in the short term and recur in the long term due to | Effects would be adverse, negligible to moderate in magnitude, and local in extent in the short-, medium-, and long- term due to scheduled/routine maintenance, major maintenance and rehabilitation, and structural measures. Major, local, adverse effects would occur in the short term and recur in the long term due to |

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| | | drawdowns. Adverse effects would be less severe than all other action alternatives because Alternative 1 includes only one recurring drawdown and does not include the suite of near-term operations. Alternative 1 is the only action alternative that would result in direct benefits to recreation by promoting reservoir storage (i.e., from reducing minimum flows to congressionally authorized minimum flows). All other alternatives would only result in indirect benefits to recreation over time by improving recreational fishing. | drawdowns. Adverse effects would be more severe than Alternative 1 but less severe than Alternatives 2B, 3A, 3B, 4, and 5 due to the number of recurring drawdowns. | drawdowns. Adverse effects would be the same as Alternative 5, more severe than Alternatives 1 and 2A, but less severe than Alternatives 3A, 3B, or 4 due to the number of recurring drawdowns. | drawdowns. Adverse effects would be less severe than Alternative 3B but more severe than Alternatives 1, 2A, 2B, 4, and 5 due to the number of recurring drawdowns. | drawdowns. Adverse effects would be more severe than any other action alternative because it would involve the most recurring drawdowns, including the deeper drawdown to Cougar's DT. Alternative 3B would only be slightly more adverse than Alternative 3A as they would involve the same number of recurring drawdowns, but Alternative 3B would also require the construction of the tower and bridge in order to draw-down Cougar Reservoir to the DT. | drawdowns. Adverse effects would be more severe than Alternatives 1, 2A, 2B and 5, but less severe than Alternatives 3A and 3B due to the number of recurring drawdowns, inclusion of the near-term operations, and number of medium-term construction measures. | drawdowns. Adverse effects would be the same as Alternative 2B, more severe than Alternatives 1, and 2A, but less severe than Alternatives 3A, 3B, or 4 due to the number of recurring drawdowns. |
| 3.15 Land Use | Effects would be moderate in magnitude, local in extent, and long-term recurring at Fall Creek due to the drawdowns. There would be no other effects. | Effects would be minor in magnitude, local in extent, and long-term in duration due to restoring upstream and downstream passage at drop structures and maintaining revetments using nature-based engineering methods. Moderate, local, and long-term recurring effects would continue due to the drawdowns. Effects would be less than under all other action alternatives because it would have the fewest recurring drawdowns and would | Effects would be minor in magnitude, local in extent, and long-term in duration due to maintaining revetments using nature-based engineering methods. Moderate, local, and long-term recurring effects would occur due to the drawdowns and suite of near-term operations. Effects would be greater than under Alternatives 1 and 4, but less than under Alternatives 2B, 3A, 3B, and 5 due to the number of drawdowns. Effects from maintaining revetments using | Effects would be minor in magnitude, local in extent, and long-term in duration due to maintaining revetments using nature-based engineering methods. Moderate, local, and long-term recurring effects would occur due to the drawdowns and suite of near-term operations. Effects would be greater than under Alternatives 1, 2A, and 4, the same as under Alternative 5, and less than under Alternatives 3A and 3B. Effects from maintaining revetments using | Effects would be minor in magnitude, local in extent, and long-term in duration due to maintaining revetments using nature-based engineering methods. Moderate, local, and long-term recurring effects would occur due to the drawdowns and suite of near-term operations. Effects would be the same as under Alternative 3B, which would be more severe than under any other action alternatives. Effects from maintaining revetments using | Effects would be minor in magnitude, local in extent, and long-term in duration due to maintaining revetments using nature-based engineering methods. Moderate, local, and long-term recurring effects would occur due to the drawdowns and suite of near-term operations. Effects would be the same as under Alternative 3A, which would be more severe than under any other action alternatives. Effects from maintaining revetments using | Effects would be minor in magnitude, local in extent, and long-term in duration due to restoring upstream and downstream passage at drop structures and maintaining revetments using nature-based engineering methods. Moderate, local, and long-term recurring effects would continue due to the drawdowns. Effects would be less than under all other action alternatives because it would have the fewest recurring drawdowns and would | Effects would be minor in magnitude, local in extent, and long-term in duration due to maintaining revetments using nature-based engineering methods. Moderate, local, and long-term recurring effects would occur due to the drawdowns and suite of near-term operations. Effects would be greater than under Alternatives 1, 2A, and 4, the same as under Alternative 2B, and less than under Alternatives 3A and 3B. Effects from maintaining revetments using |

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| | | not include the suite of near-term operations. | nature-based engineering methods would be less than under Alternatives 1 and 4 and the same as under all other action alternatives. | nature-based engineering methods would be less than under Alternatives 1 and 4 and the same as under all other action alternatives. | nature-based engineering methods would be less than under Alternatives 1 and 4 and the same as under all other action alternatives. | nature-based engineering methods would be less than under Alternatives 1 and 4 and the same as under all other action alternatives. | not include the suite of near-term operations. | nature-based engineering methods would be less than under Alternatives 1 and 4 and the same as under all other action alternatives. |
| 3.16 Hazardous Materials | The effects would be adverse and negligible to minor in magnitude, short-, medium-, and long-term in duration, and local to regional in extent. Short- and medium-term negligible to minor adverse effects would be local in extent and occur primarily due to construction, demolition, and maintenance. Long-term minor adverse effects would occur due to the operation of oil-filled systems, primarily those for hydropower generation, where effects could be up to regional in extent due to the potential for downstream discharge. | The effects would be adverse and negligible to minor in magnitude, short-, medium-, and long-term in duration, and local to regional in extent. Short- and medium-term, negligible to minor, local, and adverse, effects would occur primarily due to construction projects. Long-term, negligible, local effects would occur due to the operation of new structures that would require oil-filled systems, such as WTC towers and an AFF. These effects would be greater than alternatives 2A, 2B, 3A, 3B, and 5, but less than Alternative 4, due to the number of medium-term construction projects. | The effects would be adverse and negligible to minor in magnitude, short-, medium-, and long-term in duration, and local to regional in extent. Short- and medium-term, negligible to minor, local, and adverse, effects would occur primarily due to construction projects. Long-term, negligible, local effects would occur due to the operation of new structures that would require oil-filled systems, such as a WTC tower and an AFF. These effects would be the same as Alternative 3A, greater than Alternatives 2B and 5, but less than Alternatives 3B and 4. | The effects would be adverse and negligible to minor in magnitude, short-, medium-, and long-term in duration, and local to regional in extent. Short- and medium-term, negligible to minor, local, and adverse, effects would occur primarily due to construction projects. Long-term, negligible, local effects would occur due to the operation of new structures that would require oil-filled systems, such as a WTC tower and an AFF. These effects would be the same as Alternative 5 and less than all other action alternatives because Alternatives 2B and 5 include the fewest short- and medium-term construction projects. | The effects would be adverse and negligible to minor in magnitude, short-, medium-, and long-term in duration, and local to regional in extent. Short- and medium-term, negligible to minor, local, and adverse, effects would occur primarily due to construction projects. Long-term, negligible, local effects would occur due to the operation of new structures that would require oil-filled systems, such as AFFs. These effects would be the same as Alternative 2A, greater than Alternatives 2B and 5, and less than Alternatives 1, 3B, and 4. | The effects would be adverse and negligible to minor in magnitude, short-, medium-, and long-term in duration, and local to regional in extent. Short- and medium-term, negligible to minor, local, and adverse, effects would occur primarily due to construction projects. Long-term, negligible, local effects would occur due to the operation of new structures that would require oil-filled systems, such as AFFs. These effects would be greater than Alternatives 2A, 2B, and 5, but less than Alternatives 1 and 4. | The effects would be adverse and negligible to minor in magnitude, short-, medium-, and long-term in duration, and local to regional in extent. Short- and medium-term, negligible to minor, local, and adverse, effects would occur primarily due to construction projects. Long-term, negligible, local effects would occur due to the operation of new structures that would require oil-filled systems, such as WTC towers and an AFF. These effects would be greater than all other action alternatives due to the number of medium-term construction projects that would occur. | The effects would be adverse and negligible to minor in magnitude, short-, medium-, and long-term in duration, and local to regional in extent. Short- and medium-term, negligible to minor, local, and adverse, effects would occur primarily due to construction projects. Long-term, negligible, local effects would occur due to the operation of new structures that would require oil-filled systems, such as a WTC tower and an AFF. These effects would be the same as Alternative 2B and less than all other action alternatives because Alternatives 2B and 5 include the fewest short- and medium-term construction projects. |
| 3.17 Public Health and Safety – Hazardous Algal Blooms | The effects of temperature control, TDG reduction, maintaining flow target, passing water over the spillway measures and the Fall Creek Drawdown would be beneficial and/or adverse minor, large, short and long term recurring. The effects of | Alternative 1 effects would be adverse negligible, small or large for the construction and/or modification of any structural measures, the continued operation of adult fish facilities, and routine and non-routine maintenance in the short term or medium term and long | Alternative 2A effects would be adverse negligible, small or large for the construction and/or modification of any structural measures, the continued operation of adult fish facilities, and routine and non-routine maintenance in the short term or medium term and long | Alternative 2B effects would be adverse negligible, small or large for the construction and/or modification of any structural measures, the continued operation of adult fish facilities, and routine and non-routine maintenance in the short term or medium term and long | Alternative 3A effects would be adverse negligible, small or large for the construction and/or modification of any structural measures, the continued operation of adult fish facilities, and routine and non-routine maintenance in the short term or medium term and long | Alternative 3B effects would be adverse negligible, small or large for the construction and/or modification of any structural measures, the continued operation of adult fish facilities, and routine and non-routine maintenance in the short term or medium term and long | Alternative 4 effects would be adverse negligible, small or large for the construction and/or modification of any structural measures, the continued operation of adult fish facilities, and routine and non-routine maintenance in the short term or medium term and long | Alternative 5 effects would be adverse negligible, small or large for the construction and/or modification of any structural measures, the continued operation of adult fish facilities, and routine and non-routine maintenance in the short term or medium term and long |

| Resource Topic | NAA | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
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| | augmenting flows would have adverse minor, small, short- and long-term recurring effects. The effects of continued operation of adult fish facilities and routine and non-routine maintenance would be adverse, negligible, small, in the short and long term recurring and large in the medium- and long term recurring for major maintenance. | term recurring; and in the medium- and long term recurring for major maintenance. Effects of water management measures and the Fall Creek drawdown would be beneficial and/or adverse, minor, large, short and long-term recurring. Alternative 1 likely has be most severe impacts to due the emphasis on storage where sediment and nutrients would accumulate causing a higher likelihood of a HABs event occurring within the reservoirs. | term recurring; and in the medium- and long term recurring for major maintenance. Effects of water management measures; the Fall Creek drawdown; and the Near-Term Operations Measure would be beneficial and/or adverse, minor, large, short and long-term recurring. Alternative 2A has similar but less severe effects than Alternative 1. | term recurring; and in the medium- and long term recurring for major maintenance. Effects of water management measures; the Fall Creek drawdown; and the Near-Term Operations Measure would be beneficial and/or adverse, minor, large, short and long-term recurring. Alternative 2B effects would be similar to Alternative 1 and 2A but less severe than Alternative 1. | term recurring; and in the medium- and long term recurring for major maintenance. Effects of water management measures; the Fall Creek drawdown; and the Near-Term Operations Measure would be beneficial and/or adverse, minor, large, short and long-term recurring. Alternative 3A effects would be similar to Alternative 1, 2A, and 2B but would be less severe than Alternative 1. | term recurring; and in the medium- and long term recurring for major maintenance. Effects of water management measures; the Fall Creek drawdown; and the Near-Term Operations Measure would be beneficial and/or adverse, minor, large, short and long-term recurring. Alternative 3B effects would be similar to Alternative 1, 2A, 2B, and 3A but would be less severe than Alternative 1. | term recurring or permanent; and in the medium- and long term recurring for major maintenance. Effects of water management measures; the Fall Creek drawdown; and the Near-Term Operations Measure would be beneficial and/or adverse, minor, large, short and long-term recurring. Alternative 4 has less drawdowns while also improving water quality and overall would have less severe and more beneficial impacts compared to the other alternatives. | term recurring or permanent; and in the medium- and long term recurring for major maintenance. Effects of water management measures; the Fall Creek drawdown; and the Near-Term Operations Measure would be beneficial and/or adverse, minor, large, short and long-term recurring. Alternatives 5 is similar to Alternative 4 as it has less drawdowns while also improving water quality and overall would have less severe and more beneficial impacts compared to the other alternatives. |
| 3.18 Public Health and Safety – Hazardous Materials | The effects would be adverse and negligible to minor in magnitude and local in extent in the short-, medium-, and long-term due to ongoing operation, maintenance, repair, replacement, and rehabilitation. Minor to moderate, adverse, state-wide effects would occur in the long term due to Oregon's mercury contamination. | The effects would be negligible to minor in magnitude and local in extent in the short-, medium-, and long term due to routine/scheduled maintenance, major maintenance and rehabilitation, and construction measures. Effects would be greater than Alternatives 2A, 2B, 3A, 3B, and 5, but less than Alternative 4 due to the number of construction activities with medium- and long-term effects. | The effects would be negligible to minor in magnitude and local in extent in the short-, medium-, and long term due to routine/scheduled maintenance, major maintenance and rehabilitation, and construction measures. Effects would be greater than Alternatives 2B and 5, but less than Alternatives 1, 3A, 3B, and 4 due to the number of construction activities with medium- and long-term effects. | The effects would be negligible to minor in magnitude and local in extent in the short-, medium-, and long term due to routine/scheduled maintenance, major maintenance and rehabilitation, and construction measures. Effects would be the same as Alternative 5 and less than all other action alternatives due to the number of construction activities with medium- and long-term effects. | The effects would be negligible to minor in magnitude and local in extent in the short-, medium-, and long term due to routine/scheduled maintenance, major maintenance and rehabilitation, and construction measures. Due to drawdowns at Blue River, there would be minor, adverse, local, long-term recurring effects. Effects would be greater than Alternatives 2A, 2B, and 5, but less than Alternatives 1, 3B, and 4 due to the recurring drawdowns at Blue River. | The effects would be negligible to minor in magnitude and local in extent in the short-, medium-, and long term due to routine/scheduled maintenance, major maintenance and rehabilitation, and construction measures. Due to drawdowns at Blue River, there would be minor, adverse, local, long-term recurring effects. Effects would be greater than Alternatives 2A, 2B, 3A, and 5, but less than Alternatives 1 and 4 due to the recurring drawdowns at Blue River and the | The effects would be negligible to minor in magnitude and local in extent in the short-, medium-, and long term due to routine/scheduled maintenance, major maintenance and rehabilitation, and construction measures. Due to drawdowns at Blue River, there would be minor, adverse, local, long-term recurring effects. Effects would be greater than Alternatives 1, 2A, 2B, 3A, 3B, and 5 due to the number of construction activities with medium- and long-term effects. | The effects would be negligible to minor in magnitude and local in extent in the short-, medium-, and long term due to routine/scheduled maintenance, major maintenance and rehabilitation, and construction measures. Effects would be the same as Alternative 2B and less than all other action alternatives due to the number of construction activities with medium- and long-term effects. |

| Resource Topic | NAA | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| | | | | | | construction of the tower and bridge in order to draw-down Cougar Reservoir to the DT. | | |
| 3.19 Public Health and Safety – Drinking Water | Effects of temperature control, TDG reduction measures, passing water over the spillway; the Fall Creek drawdown would be beneficial and adverse minor, large, short and long term recurring.<br><br>The effects of augmenting flows, routine and non-routine maintenance would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large short- and long-term; and in the medium- and long-term recurring effects for major maintenance. | Alternative 1 effects would be adverse negligible, small or large for the construction and/or modification of any structural measures, the continued operation of adult fish facilities, and routine and non-routine maintenance in the short term or medium term and long term recurring; and in the medium- and long term recurring for major maintenance.<br>Effects of water management measures and the Fall Creek drawdown would be beneficial and/or adverse, minor, large, short and long-term recurring.<br>Alternative 1 effects would be less adverse than Alternatives 2B, 3A, 3B as it has no spring drawdown and it emphasizes storage. | Alternative 2A effects would be adverse negligible, small or large for the construction and/or modification of any structural measures, the continued operation of adult fish facilities, and routine and non-routine maintenance in the short term or medium term and long term recurring; and in the medium- and long term recurring for major maintenance.<br>Effects of water management measures; the Fall Creek drawdown; and the Near-Term Operations Measure would be beneficial and/or adverse, minor, large, short and long-term recurring.<br>Alternative 1 effects would be less adverse than Alternatives 2B, 3A, 3B as it has no spring drawdown and promotes water quality. | Alternative 2B effects would be adverse negligible, small or large for the construction and/or modification of any structural measures, the continued operation of adult fish facilities, and routine and non-routine maintenance in the short term or medium term and long term recurring; and in the medium- and long term recurring for major maintenance.<br>Effects of water management measures; the Fall Creek drawdown; and the Near-Term Operations Measure would be beneficial and/or adverse, minor, large, short and long-term recurring and beneficial negligible to minor, large, short- and long-term recurring effects.<br>Alternatives 2B, 3A, and 3B would have the most adverse effects due to the spring drawdown as compared to Alternatives 1, 2A, 4, and 5. | Alternative 3A effects would be adverse negligible, small or large for the construction and/or modification of any structural measures, the continued operation of adult fish facilities, and routine and non-routine maintenance in the short term or medium term and long term recurring; and in the medium- and long term recurring for major maintenance.<br>Effects of water management measures; the Fall Creek drawdown; and the Near-Term Operations Measure would be beneficial and/or adverse, minor, large, short and long-term recurring and beneficial negligible to minor, large, short- and long-term recurring effects.<br>Alternatives 2B, 3A, and 3B would have the most adverse effects due to the spring drawdown as compared to Alternatives 1, 2A, 4, and 5. | Alternative 3B effects would be adverse negligible, small or large for the construction and/or modification of any structural measures, the continued operation of adult fish facilities, and routine and non-routine maintenance in the short term or medium term and long term recurring; and in the medium- and long term recurring for major maintenance.<br>Effects of water management measures; the Fall Creek drawdown; and the Near-Term Operations Measure would be beneficial and/or adverse, minor, large, short and long-term recurring and beneficial negligible to minor, large, short- and long-term recurring effects.<br>Alternatives 2B, 3A, and 3B would have the most adverse effects due to the spring drawdown as compared to Alternatives 1, 2A, 4, and 5. | Alternative 4 effects would be adverse negligible, small or large for the construction and/or modification of any structural measures, the continued operation of adult fish facilities, and routine and non-routine maintenance in the short term or medium term and long term recurring or permanent; and in the medium- and long term recurring for major maintenance.<br>Effects of water management measures; the Fall Creek drawdown; and the Near-Term Operations Measure would be beneficial and/or adverse, minor, large, short and long-term recurring and beneficial negligible to minor, large, short- and long-term recurring effects.<br>Alternative 4 effects would be less adverse than Alternatives 2B, 3A, 3B as it has no spring drawdown and promotes water quality. | Alternative 5 effects would be adverse negligible, small or large for the construction and/or modification of any structural measures, the continued operation of adult fish facilities, and routine and non-routine maintenance in the short term or medium term and long term recurring or permanent; and in the medium- and long term recurring for major maintenance.<br>Effects of water management measures; the Fall Creek drawdown; and the Near-Term Operations Measure would be beneficial and/or adverse, minor, large, short and long-term recurring and beneficial negligible to minor, large, short- and long-term recurring effects.<br>Alternative 5 effects would be less adverse than Alternative 4 as it has no spring drawdown, promotes water quality and has less drawdowns. |
| 3.20 Environmental Justice | Effects to socioeconomics due to creation of additional construction jobs would | Effects to socioeconomics due to creation of additional construction jobs would | Effects to socioeconomics due to creation of additional construction jobs would | Effects to socioeconomics due to creation of additional construction jobs would | Effects to socioeconomics due to creation of additional construction jobs would | Effects to socioeconomics due to creation of additional construction jobs would | Effects to socioeconomics due to creation of additional construction jobs would | Effects to socioeconomics due to creation of additional construction jobs would |

| Resource Topic | NAA | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| | be beneficial, negligible magnitude, short-term and medium-term duration, and medium extent. Effects to the health and well-being of EJ communities hired to work at the project locations would be adverse, negligible to minor magnitude, medium-term duration, and small extent due to construction-related air emissions, noise, traffic, and visual disturbances. Effects on Tribes due to impacts to subsistence fishing would be adverse, moderate magnitude, long-term duration, and large extent due to projected decline in fish populations in the WRB. Impacts to Tribal recreation would be adverse, major magnitude, short-term and long-term recurring, and small extent due to restrictions on visitation and/or recreation during reservoir drawdowns. | be beneficial, minor magnitude, short-term and medium-term duration, and medium extent. Effects to the health and well-being of EJ communities hired to work at the project locations and residing in the vicinity of the project locations would be adverse, minor to moderate magnitude, short-term and medium-term duration, and small and medium extent due to construction-related air emissions, noise, traffic, and visual disturbances. Effects on Tribes due to impacts to subsistence fishing would be adverse, minor to moderate magnitude, long-term duration, and large extent due to projected decline in fish populations in the WRB, though implementation of project measures would ensure that the effects would be less adverse that those currently experienced. Impacts to Tribal recreation would be adverse, major magnitude, short-term and long-term recurring, and small extent due to restrictions on visitation and/or recreation during reservoir drawdowns. | be beneficial, medium extent, and negligible to minor magnitude in the short term and medium term, but negligible in the long term. Effects to the health and well-being of EJ communities hired to work at the project locations and residing in the vicinity of the project locations would be adverse, negligible to moderate magnitude, short-term and medium-term duration, and small and medium extent due to construction-related air emissions, noise, traffic, and visual disturbances. Effects on Tribes due to impacts to subsistence fishing would be adverse, minor to moderate magnitude, long-term duration, and large extent due to projected decline in fish populations in the WRB, though implementation of project measures would ensure that the effects would be less adverse that those currently experienced by Tribes. Impacts to Tribal recreation would be adverse, major magnitude, short-term and long-term recurring, and small extent due to restrictions on visitation and/or recreation during reservoir drawdowns. | be beneficial, medium extent, and negligible to minor magnitude in the short term and medium term, but negligible in the long term. Effects to the health and well-being of EJ communities hired to work at the project locations and residing in the vicinity of the project locations would be adverse, negligible to moderate magnitude, short-term and medium-term duration, and small and medium extent due to construction-related air emissions, noise, traffic, and visual disturbances. Effects on Tribes due to impacts to subsistence fishing would be adverse, minor to moderate magnitude, long-term duration, and large extent due to projected decline in fish populations in the WRB, though implementation of project measures would ensure that the effects would be less adverse that those currently experienced by Tribes. Impacts to Tribal recreation would be adverse, major magnitude, short-term and long-term recurring, and small extent due to restrictions on visitation and/or recreation during reservoir drawdowns. | be beneficial, medium extent, and negligible to minor magnitude in the short term and medium term, but negligible in the long term. Effects to the health and well-being of EJ communities hired to work at the project locations and residing in the vicinity of the project locations would be adverse, negligible magnitude, short-term and medium-term duration, medium extent due to construction-related air emissions, noise, traffic, and visual disturbances. Effects on Tribes due to impacts to subsistence fishing would be adverse, minor magnitude, long-term duration, and large extent due to projected decline in fish populations in the WRB, though implementation of project measures would ensure that the effects would be less adverse that those currently experienced by Tribes. Impacts to Tribal recreation would be adverse, major magnitude, short-term and long-term recurring, and small extent due to restrictions on visitation and/or recreation during reservoir drawdowns. | be beneficial, medium extent, and negligible to minor magnitude in the short term and medium term, but negligible in the long term. Effects to the health and well-being of EJ communities hired to work at the project locations and residing in the vicinity of the project locations would be adverse, negligible magnitude, short-term and medium-term duration, medium extent due to construction-related air emissions, noise, traffic, and visual disturbances. Effects on Tribes due to impacts to subsistence fishing would be adverse, minor magnitude, long-term duration, and large extent due to projected decline in fish populations in the WRB, though implementation of project measures would ensure that the effects would be less adverse that those currently experienced by Tribes. Impacts to Tribal recreation would be adverse, major magnitude, short-term and long-term recurring, and small extent due to restrictions on visitation and/or recreation during reservoir drawdowns. | be beneficial, medium extent, and minor magnitude in the short term and medium term, but negligible in the long term. Effects to the health and well-being of EJ communities hired to work at the project locations and residing in the vicinity of the project locations would be adverse, negligible to moderate magnitude, short-term and medium-term duration, and small and medium extent due to construction-related air emissions, noise, traffic, and visual disturbances. Effects on Tribes due to impacts to subsistence fishing would be adverse, minor to moderate magnitude, long-term duration, and large extent due to projected decline in fish populations in the WRB, though implementation of project measures would ensure that the effects would be less adverse that those currently experienced by Tribes. Impacts to Tribal recreation would be adverse, major magnitude, short-term and long-term recurring, and small extent due to restrictions on visitation and/or recreation during reservoir drawdowns. | be beneficial, medium extent, and negligible to minor magnitude in the short term and medium term, but negligible in the long term. Effects to the health and well-being of EJ communities hired to work at the project locations and residing in the vicinity of the project locations would be adverse, negligible to moderate magnitude, short-term and medium-term duration, and small and medium extent due to construction-related air emissions, noise, traffic, and visual disturbances. Effects on Tribes due to impacts to subsistence fishing would be adverse, minor to moderate magnitude, long-term duration, and large extent due to projected decline in fish populations in the WRB, though implementation of project measures would ensure that the effects would be less adverse that those currently experienced by Tribes. Impacts to Tribal recreation would be adverse, major magnitude, short-term and long-term recurring, and small extent due to restrictions on visitation and/or recreation during reservoir drawdowns. |

| Resource Topic | NAA | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
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| 3.21 Cultural Resources | Major Effects<br><br>Ongoing major effects to cultural resources at all reservoirs resulting from reservoir fluctuations. | Major Effects<br><br>Ongoing major effects to cultural resources at all reservoirs resulting from reservoir fluctuations. | Major Effects<br><br>Ongoing major effects to cultural resources at all reservoirs resulting from reservoir fluctuations. | Major Effects<br><br>Ongoing major effects to cultural resources at all reservoirs resulting from reservoir fluctuations. | Major Effects<br><br>Ongoing major effects to cultural resources at all reservoirs resulting from reservoir fluctuations. | Major Effects<br><br>Ongoing major effects to cultural resources at all reservoirs resulting from reservoir fluctuations. | Major Effects<br><br>Ongoing major effects to cultural resources at all reservoirs resulting from reservoir fluctuations. | Major Effects<br><br>Ongoing major effects to cultural resources at all reservoirs resulting from reservoir fluctuations. |
| 3.22 Visual Resources | The effects would be moderate in the short term and large in extent, primarily due to sediment transport during reservoir drawdowns. The effects would be major in the long term and large in extent, primarily due to reservoir drawdowns altering the basic design elements in the characteristic landscape. | The effects would be minor in the short, medium, and long term and small, medium, and large in extent, primarily due to construction activities and new structures altering the basic design elements in the characteristic landscape. The effects would be moderate in the short term and large in extent, primarily due to sediment transport during reservoir drawdowns. The effects would be major in the long term and large in extent, primarily due to reservoir drawdowns altering the basic design elements in the characteristic landscape. | The effects would be minor in the short, medium, and long term and small, medium, and large in extent, primarily due to construction activities and new structures altering the basic design elements in the characteristic landscape. The effects would be moderate in the short term and small, medium, and large in extent, primarily due to sediment transport during reservoir drawdowns. The effects would be major in the long term and small, medium, and large in extent, primarily due to reservoir drawdowns altering the basic design elements in the characteristic landscape. | The effects would be minor in the short, medium, and long term and small, medium, and large in extent, primarily due to construction activities and new structures altering the basic design elements in the characteristic landscape. The effects would be moderate in the short term and small, medium, and large in extent, primarily due to sediment transport during reservoir drawdowns. The effects would be major in the long term and small, medium, and large in extent, primarily due to reservoir drawdowns altering the basic design elements in the characteristic landscape. | The effects would be minor in the medium and long term and small and large in extent, primarily due to construction activities and new structures altering the basic design elements in the characteristic landscape. The effects would be moderate in the short term and small, medium, and large in extent, primarily due to sediment transport during reservoir drawdowns. The effects would be major in the long term and small, medium, and large in extent, primarily due to reservoir drawdowns altering the basic design elements in the characteristic landscape. | The effects would be minor in the medium and long term and small and large in extent, primarily due to construction activities and new structures altering the basic design elements in the characteristic landscape. The effects would be moderate in the short term and small, medium, and large in extent, primarily due to sediment transport during reservoir drawdowns. The effects would be major in the long term and small, medium, and large in extent, primarily due to reservoir drawdowns altering the basic design elements in the characteristic landscape. | The effects would be minor in the short, medium, and long term and small, medium, and large in extent, primarily due to construction activities and new structures altering the basic design elements in the characteristic landscape. The effects would be moderate in the short term and large in extent, primarily due to sediment transport during reservoir drawdowns. The effects would be major in the long term and large in extent, primarily due to reservoir drawdowns altering the basic design elements in the characteristic landscape. | The effects would be minor in the short, medium, and long term and small, medium, and large in extent, primarily due to construction activities and new structures altering the basic design elements in the characteristic landscape. The effects would be moderate in the short term and small, medium, and large in extent, primarily due to sediment transport during reservoir drawdowns. The effects would be major in the long term and small, medium, and large in extent, primarily due to reservoir drawdowns altering the basic design elements in the characteristic landscape. |
| 3.23 Noise | The effects would be negligible to moderate magnitude, short-term or long-term duration, and small or large extent. The effects would be primarily due to noise from water flow through penstocks, and turbines and construction equipment used for structural measures and | The effects would be negligible to moderate magnitude, short-term or medium-term duration and small or medium extent. The effects of moderate magnitude would be primarily due to noise from construction equipment used for structural measures. | The effects would be negligible to moderate magnitude, short-term or medium-term duration, and small or medium extent. The effects of moderate magnitude would be primarily due to noise from construction equipment used for structural measures. | The effects would be negligible to moderate magnitude, short-term or medium-term duration, and small or medium extent. The effects of moderate magnitude would be primarily due to noise from construction equipment used for structural measures. | The effects would be negligible to moderate magnitude, short-term or medium-term duration, and small or medium extent. The effects of moderate magnitude would be primarily due to noise from construction equipment used for structural measures. | The effects would be negligible to moderate magnitude, short-term or medium-term duration, and small or medium extent. The effects of moderate magnitude would be primarily due to noise from construction equipment used for structural measures. | The effects would be negligible to moderate magnitude, short-term or medium-term duration, and small or medium extent. The effects of moderate magnitude would be primarily due to noise from construction equipment used for structural measures. | The effects would be negligible to moderate magnitude, short-term or medium-term duration, and small or medium extent. The effects of moderate magnitude would be primarily due to noise from construction equipment used for structural measures. |

| Resource Topic | NAA | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
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| | revetments. Long-term effects would be of of negligible magnitude except for hydropower generation, which is of moderate magnitude. | There would be no long-term effects. | There would be no long-term effects. | There would be no long-term effects. | There would be no long-term effects. | There would be no long-term effects. | There would be no long-term effects. | There would be no long-term effects. |
| 3.24 Tribal Resources | The NAA does not consider lamprey passage or habitat improvement, and has minor, long-term adverse effects to wildlife and habitat. The NAA would have major adverse impacts to cultural resources and fish. The NAA does not benefit tribal resources. | Benefits and reduces adverse effects to tribal resources when compared to the NAA.<br><br>Includes lamprey passage measures.<br><br>Some reduced adverse impacts to Chinook salmon and steelhead<br><br>Minor adverse impacts for bull trout.<br><br>Moderate to major beneficial water quality effects.<br><br>Major adverse impacts to cultural resources, though slightly improved when compared with the NAA through reduced days of site exposure. | A range of beneficial to adverse effects to tribal resources.<br><br>Includes lamprey passage measures.<br><br>Minor benefits to piscivorous species, and minor to moderate adverse effects to Chinook salmon and steelhead.<br><br>Minor adverse impacts for bull trout.<br><br>More beneficial to fisheries resources when compared to the NAA.<br><br>Moderate to major water quality benefits (with the exception of moderate to major adverse effects to TDG expected at Green Peter).<br><br>Major adverse impacts to cultural resources, increased from the NAA. | A range of beneficial to adverse effects to tribal resources.<br><br>Includes lamprey passage measures.<br><br>Minor benefits to piscivorous species, and minor to moderate adverse effects to Chinook salmon and steelhead.<br><br>Minor adverse impacts for bull trout.<br><br>More beneficial to fisheries resources when compared to the NAA.<br><br>Moderate to major water quality benefits (with the exception of moderate to major adverse effects to TDG expected at Green Peter).<br><br>Major adverse impacts to cultural resources, increased from the NAA. | Most adverse effects to tribal resources.<br><br>Include lamprey passage measures.<br><br>Moderate to major adverse effects are increased for Chinook salmon, steelhead, and bull trout.<br><br>Some benefits to water quality, overall this alternative has the most adverse effects to water quality compared to the NAA<br><br>Major adverse impacts to cultural resources, greatly increased from the NAA. | Most adverse effects to tribal resources.<br><br>Include lamprey passage measures.<br><br>Moderate to major adverse effects are increased for Chinook salmon, steelhead, and bull trout.<br><br>Some benefits to water quality, overall this alternative has the most adverse effects to water quality compared to the NAA<br><br>Major adverse impacts to cultural resources, greatly increased from the NAA. | A range of beneficial to adverse effects to tribal resources.<br><br>Include lamprey passage measures.<br><br>Minor benefits to piscivorous species, and minor to moderate adverse effects to Chinook salmon and steelhead.<br><br>Minor adverse impacts for bull trout.<br><br>More beneficial to fisheries resources when compared to the NAA.<br><br>Moderate to major beneficial water quality effects.<br><br>Similar adverse impacts to cultural resources to the NAA through reduced days of site exposure. | A range of beneficial to adverse effects to tribal resources.<br><br>Includes lamprey passage measures.<br><br>Minor benefits to piscivorous species, and minor to moderate adverse effects to Chinook salmon and steelhead.<br><br>Minor adverse impacts for bull trout.<br><br>More beneficial to fisheries resources when compared to the NAA.<br><br>Moderate to major water quality benefits (with the exception of moderate to major adverse effects to TDG expected at Green Peter).<br><br>Major adverse impacts to cultural resources, increased from the NAA. |

## 3.2 HYDROLOGIC PROCESSES

### 3.2.1 Affected Environment

With a watershed of approximately 11,500 square miles, the Willamette River is located entirely within the state of Oregon, beginning south of Cottage Grove and extending approximately 187 miles to the north where it flows into the Columbia River. The Willamette River is the 13th largest river in the coterminous U.S. in terms of streamflow (annual discharge) and produces more runoff per unit area than any of the 12 larger rivers (EPA 2013b). The basin averages 75 miles in width and encompasses approximately 12 percent of the total area of the state. The Willamette Valley System (WVS) PEIS covers the basin from the reservoirs on the Willamette River and its tributaries to the Willamette Falls in Oregon City.

#### *3.2.1.1 Basin layout*

The basin is bounded by three mountain ranges: the Cascade Range to the east, the Coast Range to the west, and the Calapooya Mountains to the south. Maximum elevations exceed 10,000 feet in the Cascade Range, 4,000 feet in the Coast Range, and 6,000 feet in the Calapooya Mountains. In the upper reaches, Willamette River tributaries flow in narrow valleys with steep gradients.

Major Cascade Range tributaries include the Santiam, McKenzie, Middle Fork of the Willamette, Molalla, and Clackamas rivers. The Willamette River is also fed by major tributaries from the Coast Range, including the Long Tom, Marys, Luckiamute, Yamhill, and Tualatin rivers. At the south end of the basin, the Coast Fork of the Willamette River emerges from the Calapooya Mountains and joins the mainstem Willamette River near the City of Springfield. The average annual flow at Salem (river mile [RM] 84, drainage area of 7,280 square miles) for the water years 1910-2020 was about 24,200 cubic feet per second (cfs) or about 17.5 million acre-feet annually per USGS gage data.

Within the watershed are most of the state's population, larger cities, and major industries. The basin also contains much of Oregon's most productive agricultural lands and supports nationally and regionally important fish and wildlife species and populations. Thirteen of Oregon's 36 counties (Benton, Clackamas, Columbia, Douglas, Klamath, Lane, Linn, Marion, Multnomah, Polk, Tillamook, Washington, Yamhill) intersect or lie within the boundary of the WRB, where nearly 70 percent of Oregon's population lives.

#### *3.2.1.2 Basin climate*

Topography, proximity to the Pacific Ocean, and exposure to middle latitude westerly winds are the principal climate controls for the WRB. The basin climate ranges from warm dry summers and cool wet winters in the center of the basin to extreme alpine conditions in the highest Cascade Mountain reaches. Rainfall ranges from 40 inches per year in most of the basin to over 200 inches per year in the highest Cascade Mountain reaches. For the entire basin, average annual precipitation totals approximately 63 inches, with 60 percent falling during November through March based on rain gage and snow depth data (USACE 2015b).

During the winter months, high-pressure centers are characteristically to the south so that winds consistently come from the relatively warm and humid ocean surface and bring precipitation into the basin. In contrast, summer conditions typically have high-pressure centers near the west coast, which often forces the flow of air over the basin from a northerly direction. This pattern decreases relative humidity and reduces the amount of cloud cover and precipitation over the entire area during summer months. Thunderstorms can occur during the summer but are not a major source of precipitation in the basin. During spring and autumn, intermediate conditions occur causing alternating wet and dry periods (USACE 2015b).

#### *3.2.1.3 River System*

There are approximately 465 RM along the Willamette River and its regulated subbasins below USACE's WVS. The approximate regulated river length in each subbasin is:

- Mainstem Willamette River – 187 RM
- Mainstem Santiam River – 11 RM
- North Santiam River – 46 RM
- South Santiam River – 44 RM
- Long Tom River – 25 RM
- McKenzie River (including South Fork) – 60 RM
- Blue River – 2 RM
- Coast Fork of Willamette River – 30 RM
- Middle Fork of the Willamette River – 45 RM
- Fall Creek – 7 RM
- Row River – 8 RM

Most of the drainage area in the WRB is located downstream of the WVS dams and reservoirs. For example, although more than 90 percent of Middle Fork of the Willamette drainage passes through USACE reservoirs upstream of Eugene, only about 27 percent of the drainage area is above a reservoir at the Willamette's confluence with the Columbia River. The relative volume of water in the Willamette River from USACE reservoirs varies significantly throughout the year depending on the primary seasonal flow management goal.

#### *3.2.1.4 Flow Management Goals*

During each year there are overarching three reservoir control periods: flood risk management (FRM) (fall/winter), conservation storage (spring), and conservation holding and release (summer). The transition date between seasons varies slightly at each reservoir (USACE 2014a).

Operation of each project is guided by its water control diagram, including the rule curve, which establishes the elevation at which the pool is to be maintained at or below during various seasons and during seasonal transitions unless regulating a flood event. Figure 3.2-1 depicts a typical WVS water control diagram, including the rule curve, with the three overarching regulation seasons across the top. The main features of the water control diagram are annotated.

From September to November (or December at some projects), the reservoirs are drawn down to minimum flood pool elevations to reserve space to detain and release winter flood flows as necessary. In February (depending on the project), reservoirs begin to accumulate water in conservation storage by releasing less water than flows in. By about the end of May or June, WVS reservoirs are as full as possible for the summer season (USACE 2015b).

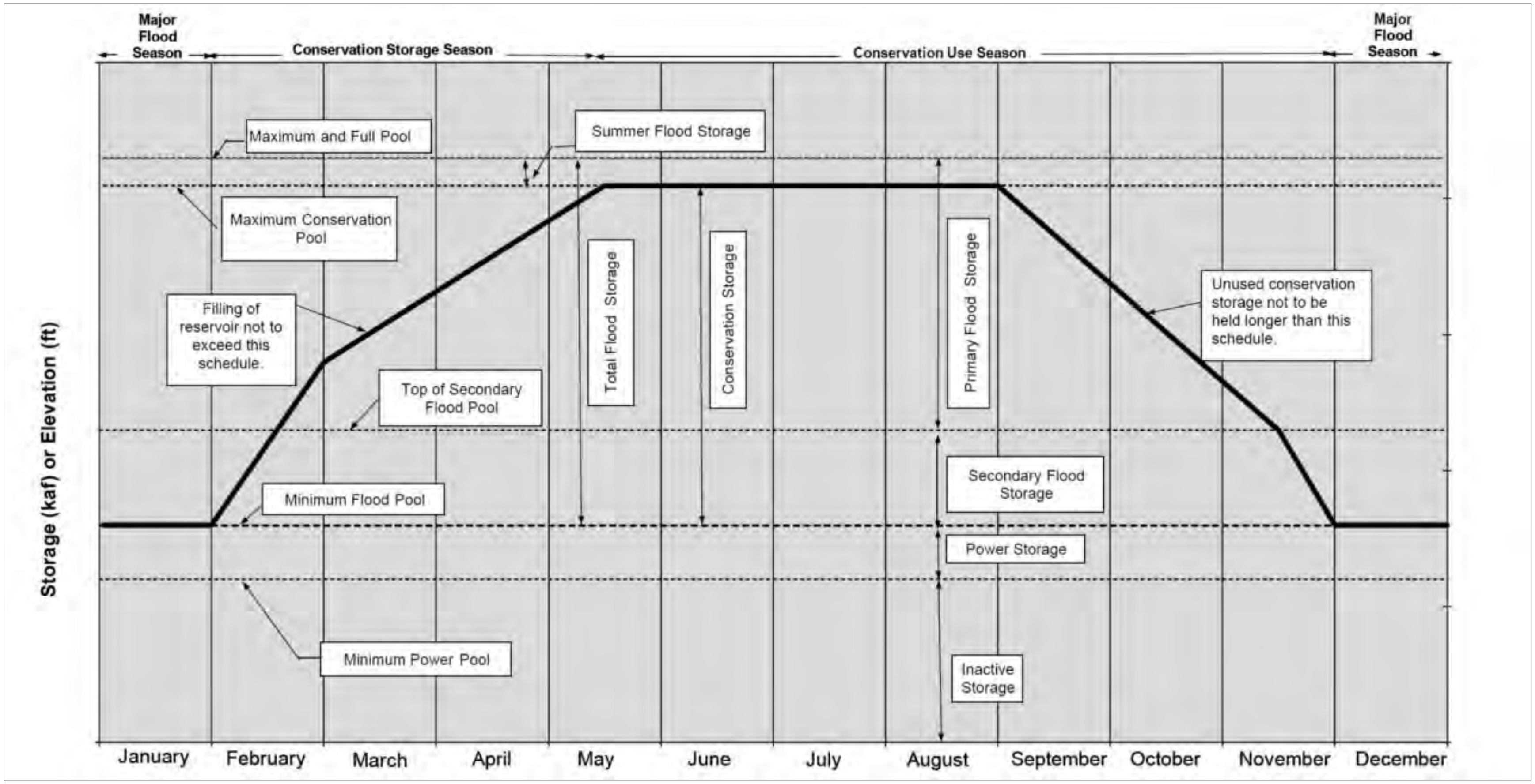



**Figure 3.2-1 Typical Willamette Basin Project Dam and Reservoir Water Control Diagram and Rule Curve**

As required by Congress, USACE manages the WVS to meet multiple responsibilities or purposes, including flood control or flood risk management (FRM), hydropower, water quality, fish and wildlife, recreation, irrigation, navigation, and municipal and industrial water supply. In some years, inflow to WVS reservoirs are not sufficient to fully meet all the demands on the system.

The goal of spring and summer flow management planning is to develop a strategy for the release of stored water using the National Oceanic and Atmospheric Administration Regional Forecast Center's (NOAA RFC) anticipated precipitation and runoff patterns. Each year, the Willamette Action Team for Ecosystem Restoration (WATER), made up of the US Fish and Wildlife Service, National Marine Fisheries Service, USACE, Bureau of Reclamation, Bonneville Power Administration, Oregon Water Resources Department, and Oregon Department of Fish and Wildlife, works cooperatively and adaptively before and during the conservation storage and release season to plan WVS operations to meet flow objectives for ESA-listed fish and management for other project purposes. Since each water year is different, this coordination is preferable to establishing fixed operating criteria. Adaptive management is necessary as it is not possible for USACE to forecast, describe, model, and implement a comprehensive release program that addresses potential management scenarios and contingencies without frequent coordination.

The Conservation Plan developed in cooperation with WATER describes individual reservoir and system flow objectives, reservoir release priorities, minimum and maximum flows, and balances the multipurpose needs given the forecasted availability of water. The general operational goal – assuming sufficient inflow of water – is to maintain each reservoir above minimum conservation pool ("Minimum Flood Pool" level in Figure 3.2-1) through October 31 while attempting to meet the other project purposes. Operational flow objectives at Salem begin on April 1, before the reservoir refill period ends in May, so WVS releases may be adjusted through the conservation season. The availability of water is reassessed as necessary (monthly, at a minimum) through October, and changes in the WVS management strategy are made in coordination with the representatives from WATER throughout the conservation season (USACE 2015b).

During the winter months, WVS reservoirs are primarily operated for FRM. There is a notable history of flooding in the Willamette Valley, with large floods occurring in 1861, 1964 and 1996. The largest historical flow at Salem was during 1861, peaking at an estimated 500,000 cfs. The 1964 and 1996 floods peaked at 308,000 cfs and 244,000 cfs respectively. Both more modern events were reduced by the WVS winter storage capacity. If the WVS had not existed during these events, the peak flows would have been much higher: approximately 472,000 cfs and 381,000 cfs (USACE 1997).

Each WVS reservoir is managed for targets at control points downstream, shown in Figure 3.2-2. These targets can apply only to an individual USACE project or to the entire system. For example, Fern Ridge flood season flow decisions are immediately evaluated at its nearest control point at Monroe on the Long Tom River and no other WVS reservoir can influence water levels at this location. Continuing downstream, the control point at Salem on the mainstem Willamette is influenced by all the WVS reservoirs. Section 3.2.1.5, Basin Description and Reservoir System, contains a more detailed explanation and maps of each subbasin.

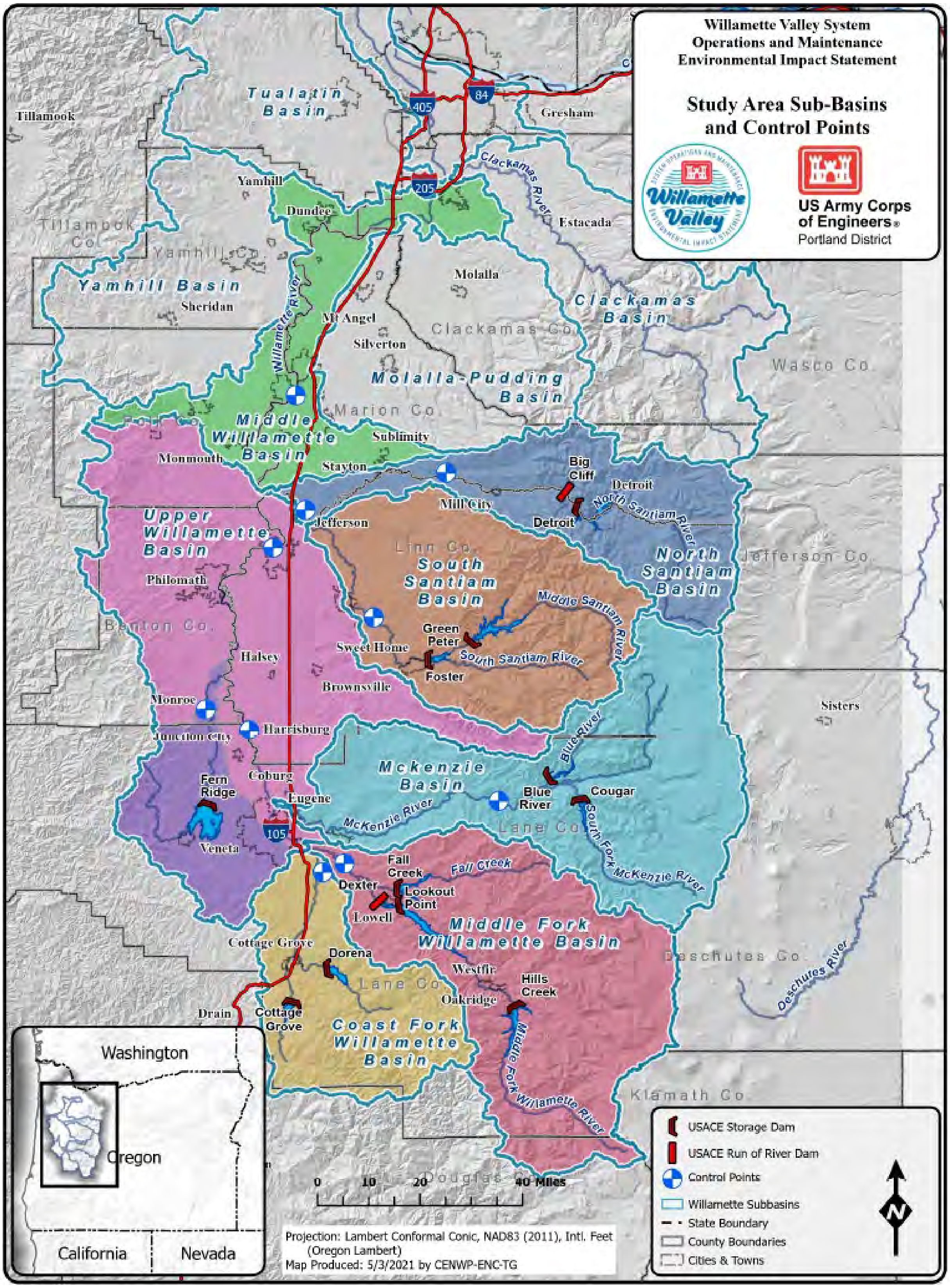



**Figure 3.2-2. Willamette River Basin subbasins and WVS layout**

Major flood season runs from the middle of November through early February in the WRB. Floods result principally from rainfall, augmented by snowmelt. House Document 531 (HD531) established the guidelines for flood season operation for the WVS and established two types of flood storage. Primary flood storage provides risk management for floods of record except for the 1861 flood, while secondary flood storage provides risk management for flows to the 1861 level. Secondary flood storage can be used jointly for FRM and hydropower purposes. The document mandates that the maximum amount of flood storage space (i.e., the bottom of secondary flood storage) at the non-power projects must be available at the start of each flood season. Current practice is to lower the water level in all projects, regardless of power generating capability and excluding the smaller reregulating projects Big Cliff and Dexter, to minimum flood storage prior to the beginning of the flood season.

As flood waters allow downstream, USACE lowers reservoir levels to the minimum flood pool elevation, which is the bottom of secondary flood storage pool. Timelines are dictated by project limitations such as flow change limits and outlet capacities, which vary at each WVS dam, but the bottom of flood storage is typically achieved in seven to ten days.

#### *3.2.1.5 Basin Description and Reservoir System*

The WVS was constructed over approximately 30 years starting with Fern Ridge (completed 1942) on the Long Tom River, west of Eugene. The complete WVS is authorized for flood control, hydropower, pollution abatement, fish and wildlife conservation, navigation (removed in 1986), recreation, irrigation, municipal and industrial water supply, and water quality. Based on the hydrologic dataset from 1935-2019, the total average annual basin flow volume is 17.2 million acre-ft (Maf) at Salem, OR and 22.7 Maf at Willamette Falls, or an annual average of 23,700 cfs and 31,300 cfs, respectively. Approximately 6.1 Maf, or an average of 8,350 cfs (35 and 27 percent of the flow at Salem and Willamette Falls, respectively), flowed through the WVS, compared to a total conservation storage volume of 1.59 Maf. Annual variability accounts for slightly different flow measurements when using different time periods for the analysis.

Construction of the 13 USACE dams and reservoirs in the WRB fundamentally changed the character of the flow regime in the watershed. The WVS moderates floods during the winter by storing and releasing water to manage flood risk. Outside of flood season, the WVS releases stored water to maintain downstream flows throughout the summer, supplementing downstream basin inflows. With ResSim and other models, USACE can calculate the effects on reducing and increasing flows at various points in the WRB. An unregulated flow refers to a natural flow regime without the influence of the WVS and an observed flow refers to the basin with the WVS in place, managing flow in the system.

Figure 3.2-3 shows a comparison between the observed and unregulated flow for the 1996 water year at Salem, OR and the daily minimum, average and maximum unregulated flow as calculated by the USGS for 1928 to 2008 (Lind and Stonewall 2018). Note the reduced peaks during the winter and increased flow during the summer and fall. Similar patterns are present across most years; 1996 was a wetter than average year and both the unregulated and regulated flows are above the median flow for most of the winter months.

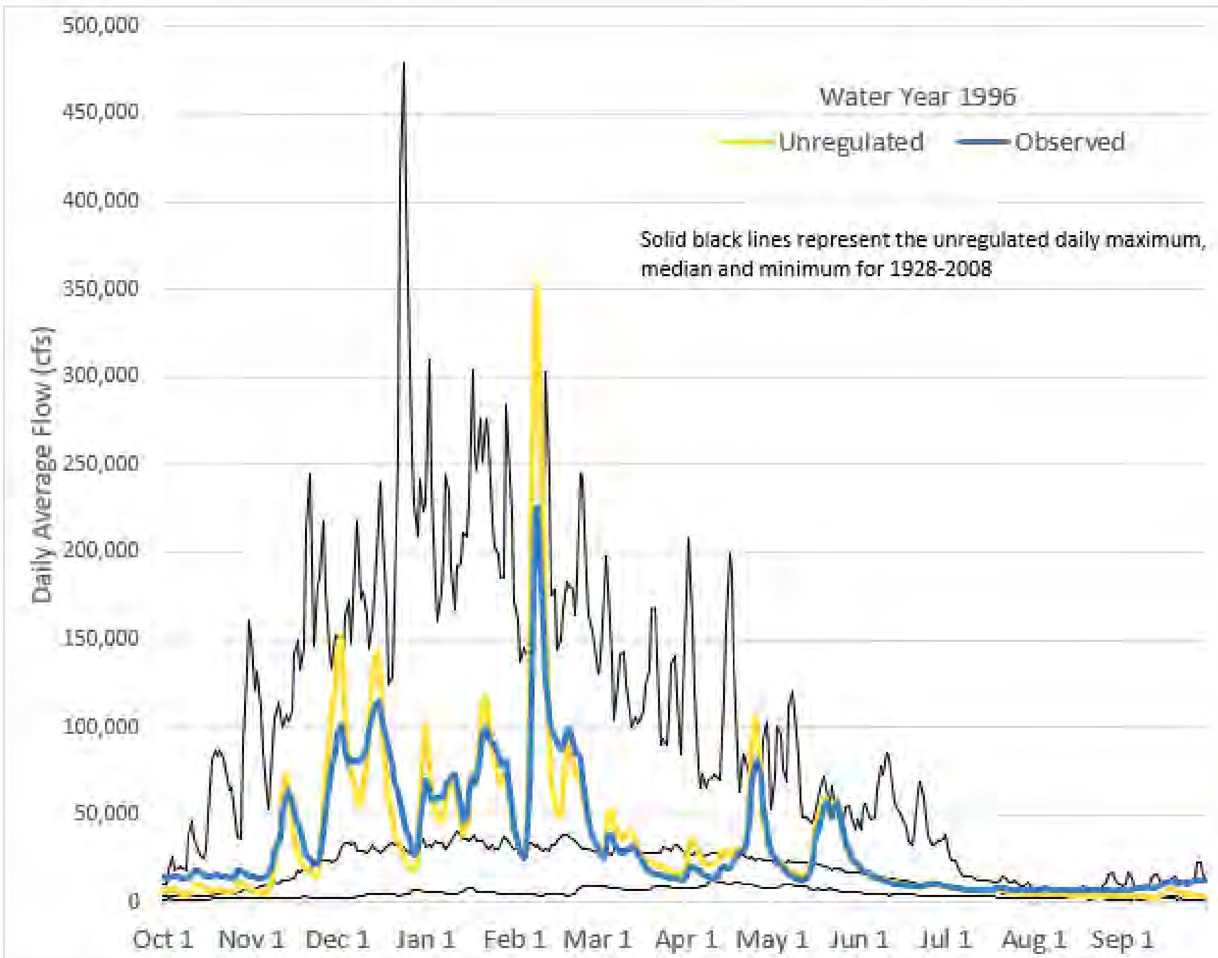



**Figure 3.2-3. Willamette River stream flows at Salem, Oregon for October 1995 to September 1996 (WY1996)**

The WVS stores water in its reservoirs and some of this water evaporates. Except at Fern Ridge, the evaporation is a relatively minor component of the total reservoir inflow – WVS reservoirs have a large volume compared to their surface area. Since inflow is calculated with the change in storage and the measured outflow, the evaporated water is already accounted for in the input dataset as a slightly lower inflow. At Fern Ridge, since it is shallower than the other WVS reservoirs and has the largest surface area, evaporation is estimated and removed from the reservoir in the ResSim model. Appendix B, Hydrologic Processes Technical Information, has additional information on the hydrologic dataset development.

WVS has target flows at the mainstem control points during the summer. The goal is to augment the natural downstream flows with stored water for fish and irrigation withdrawals. This actual target flow varies with the conditions set out in the 2008 NMFS BiOp (NMFS 2008), based on the projected amount of stored water each spring.

The hydrologic study area ends at the Willamette Falls in Oregon City, Oregon. The portion of the Willamette River flowing through Portland, Oregon, is downstream of Willamette Falls and is not included in the reservoir model, and neither is any flow coming into the river downstream of the Falls. The Willamette River below the Falls has a tidal influence that cannot be modeled in ResSim. See the Columbia River System Operations EIS for information on the tidally influenced portion of the river (USACE, et al., 2020).

###### *3.2.1.5.1 Basin Flow*

Total basin-wide inflow is not evenly distributed throughout the WRB. In general, larger size and higher elevation subbasins contribute more flow. Most of the flow from the WRB originates from areas that are not upstream of a WVS dam. For example, 1.5 percent and 2.8 percent of the total basin flow comes into Blue River and Cougar reservoirs, respectively. Much more water (8.8 percent of the total) flows into the control point at Vida below those two reservoirs without having passed through the reservoirs upstream. Moreover, about 24 percent of annual flow of the Willamette at its confluence with the Columbia enters the river from tributaries downstream of Salem, the most downstream control point for current operational targets. Figure 3.2-4 shows the origin of basin flows on an average annual basis. The values represent the additional accumulated inflow as compared to the next upstream point under natural conditions with no dams present.

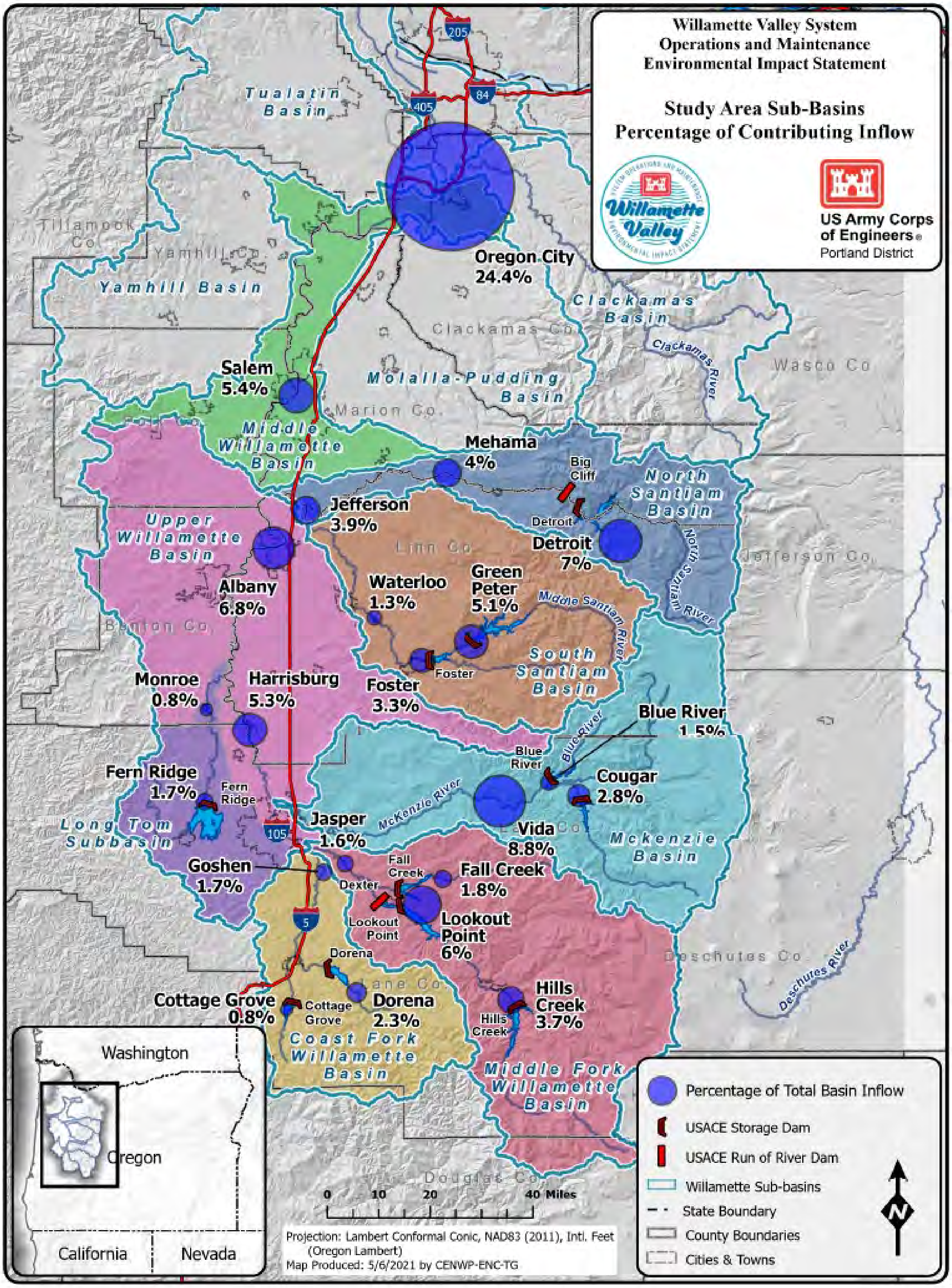



**Figure 3.2-4. Basin inflow origin by WVS and Control point location**

### *3.2.1.5.2 Unregulated and Observed Flow*

As discussed in Flow Management Goals, the primary objectives of the WVS change throughout the year based on the season. During the winter, the primary objective is FRM with a goal to reduce flows, and hence flood stages, downstream of the WVS. During the spring, the WVS holds water to fill and release the stored water through the summer and fall.

A comparison of the observed (USGS gage records after the construction of WVS) and unregulated (Lind and Stonewall 2018) flows show the effects of WVS operations. The example figures below show a reduction in peaks (the 5 percent non-exceedance line – 5 percent of years are above that threshold on that calendar day) and increased median flows from December to February. The median is higher because the water volume stored during large inflows is generally released over 7-14 days, increasing the flow of a larger number of days than peak reduction over 2-3 days. In the spring, the median observed flows go below the unregulated flow as the WVS reservoirs store water and high peaks are reduced. Later into the summer, flow augmentation from the reservoirs means that observed flow is higher than unregulated flow. In fall, the reservoirs release any remaining water to return to minimum elevation in preparation for major flood season.

Figures 3.2-5 and 3.2-6 show the water year flows at Jasper (the control point for Lookout Point and Hills Creek) and Albany, respectively. The difference in observed and unregulated flows is greater at Jasper than Albany because a much higher percentage of the drainage basin flows through a WVS dam and reservoir upstream of Jasper. Similar figures for the remaining WRB control points are available in Appendix B, Hydrologic Processes Technical Information.

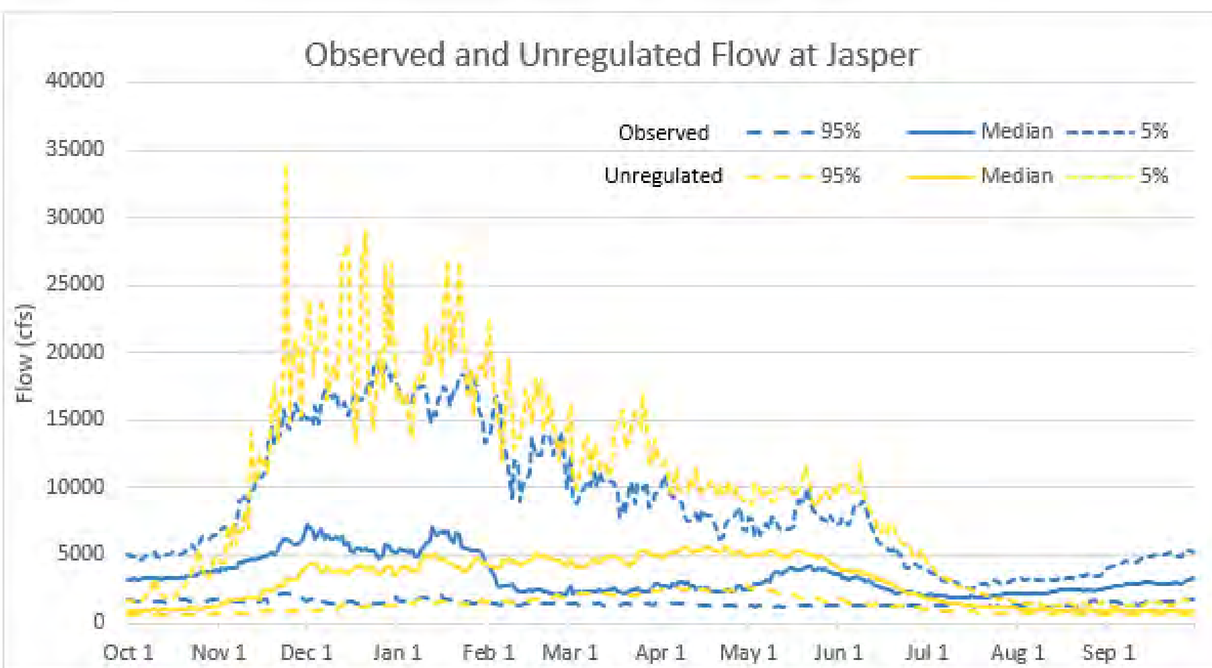



**Figure 3.2-5. Middle Fork of the Willamette River at Jasper, OR. Flows across the water year**

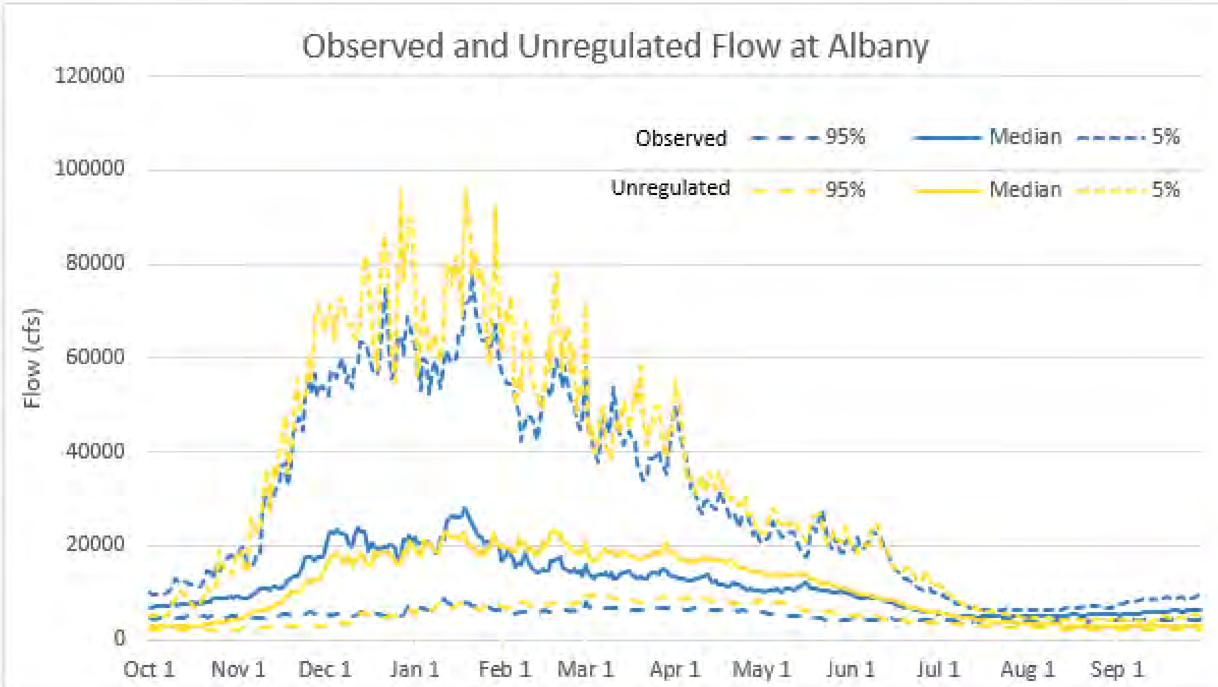



**Figure 3.2-6. Willamette River at Albany, OR. Flows across the water year**

*3.2.1.5.3 Reservoir Pool Operations*

During April and May, the WATER partners assign a rating of abundant, adequate, insufficient or deficit for the upcoming conservation storage season based on the forecasted refill volume of the WVS reservoirs. The insufficient and deficit designations change the mainstem flow targets at Albany and Salem and allowable withdrawals from the Willamette River. Water Quality (Section 3.5) used three recent prototypical years to show the range of the designations: 2011, abundant; 2015, deficit; and 2016, insufficient.

The figures below are of actual operations, not model results, for illustration purposes. WVS reservoirs were nearly full during the 2011 conservation season and stayed at or near rule curve until they were drafted (i.e., lowered) in preparation for a major flood season. Detroit reservoir (Figure 3.2-7) is operated for downstream temperature control in insufficient years, so levels stayed relatively high in 2016; maintaining the pool above the spillway crest (elevation 1541 ft) makes these operations more effective. In contrast, Green Peter (Figure 3.2-8) and Lookout Point (Figure 3.2-9) were drafted down as USACE used its stored water to meet the biological opinion mainstem flow requirements. 2015 was a deficit year, so the reservoirs did not reach the rule curve during the spring and released the stored water, going below minimum conservation pool into the power pool. Similar figures of the remaining storage reservoirs are available in Appendix B, Hydrologic Processes Technical Information.

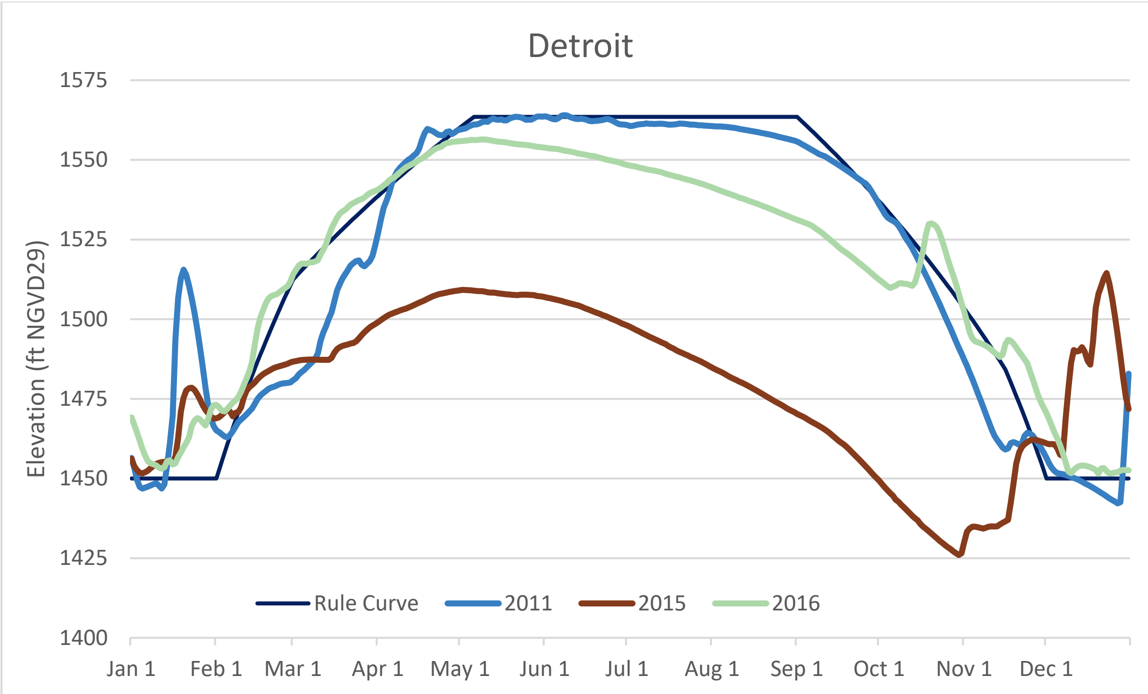



**Figure 3.2-7. Detroit reservoir water surface elevation across 2011, 2015 and 2016**

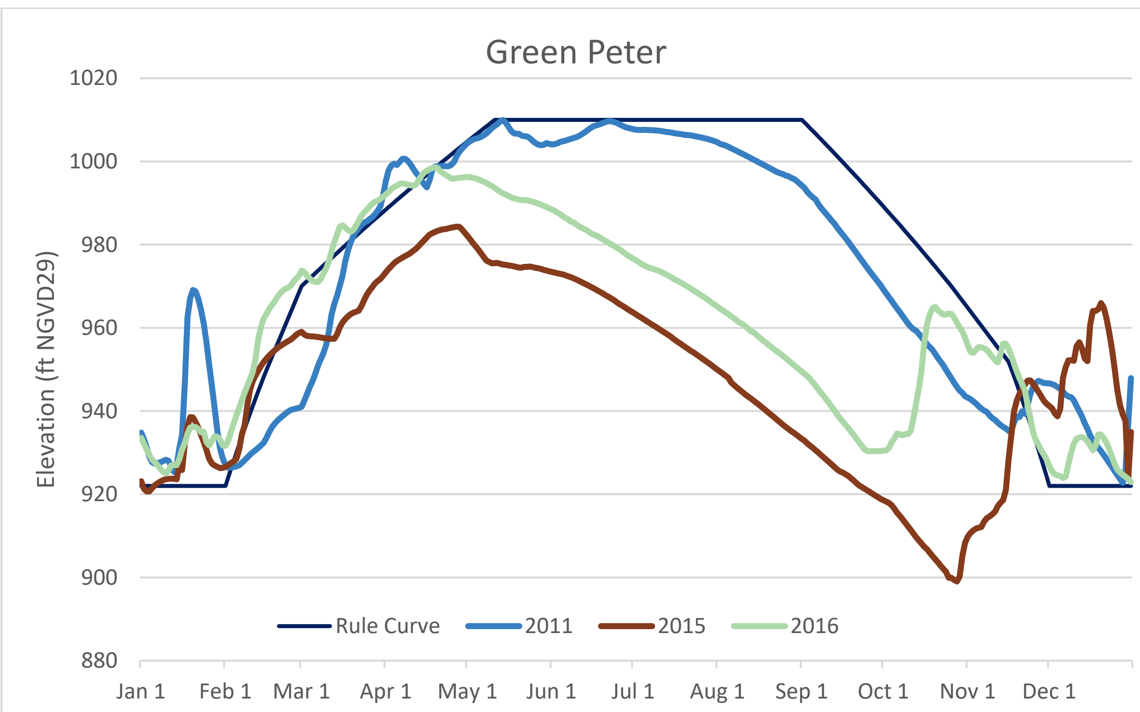



**Figure 3.2-8. Green Peter reservoir water surface elevation across 2011, 2015 and 2016**

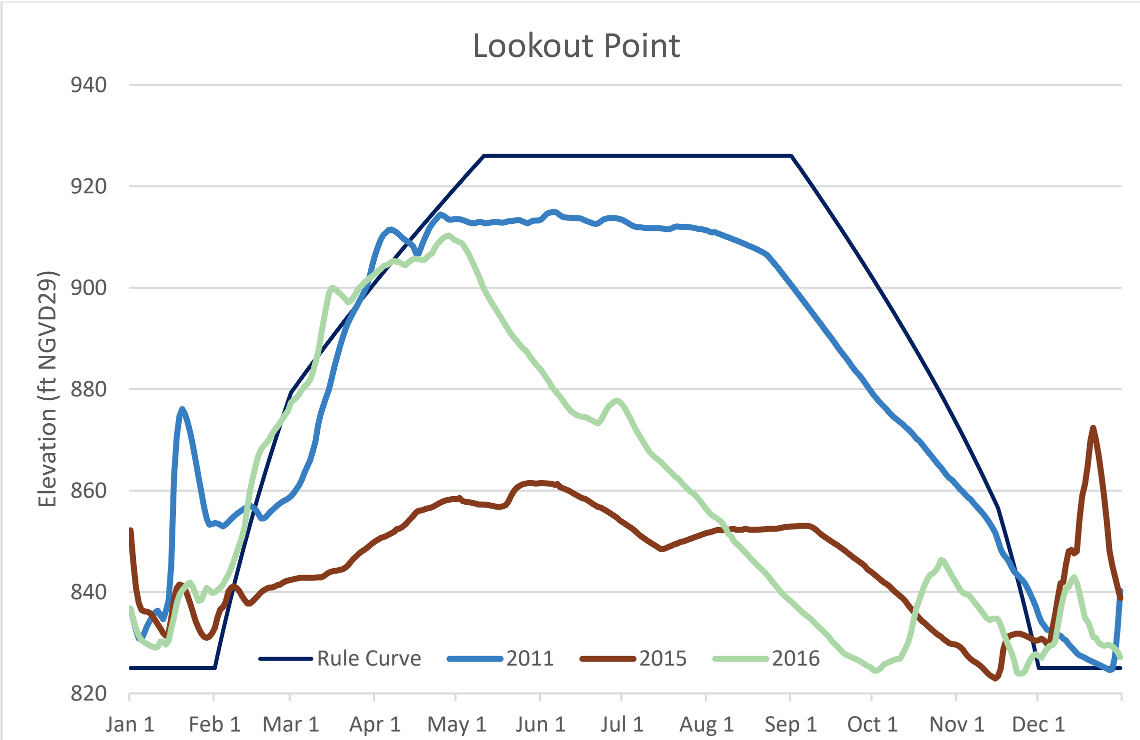



**Figure 3.2-9. Lookout Point reservoir water surface elevation across 2011, 2015 and 2016**

### *3.2.1.5.4 Mainstem Willamette*

The mainstem Willamette River subbasins are divided into three main sections. The upper portion of the mainstem Willamette River starts at the confluence between the Middle and Coast Forks and continues up to the Santiam River. The extent of the Middle Willamette stretches from the Santiam River to Willamette Falls at Oregon City. The Lower Willamette below Willamette Falls is the tidal portion of the river to the Columbia River and is not part of this study. Including the Clackamas River, which is the largest drainage basin downstream of the Falls, the Lower Willamette River is about 12 percent of WRB at its confluence with the Columbia River.

The Middle Willamette subbasin (Figure 3.2-10) is characterized by a braided meandering channel upstream of the mouth of the Yamhill River. From the Yamhill River to Willamette Falls, the river is characterized by a well-defined channel with comparatively narrow floodplain, most of which is located on its right bank. In the 5 miles above Oregon City, the river flows through a gorge upstream of the Tualatin River confluence to Willamette Falls. Above the falls, a fixed-crest hydropower dam (Thomas A. Sullivan Dam) was built and during low flows, the backwater effects of this dam extend upstream nearly 23 miles to Newberg.

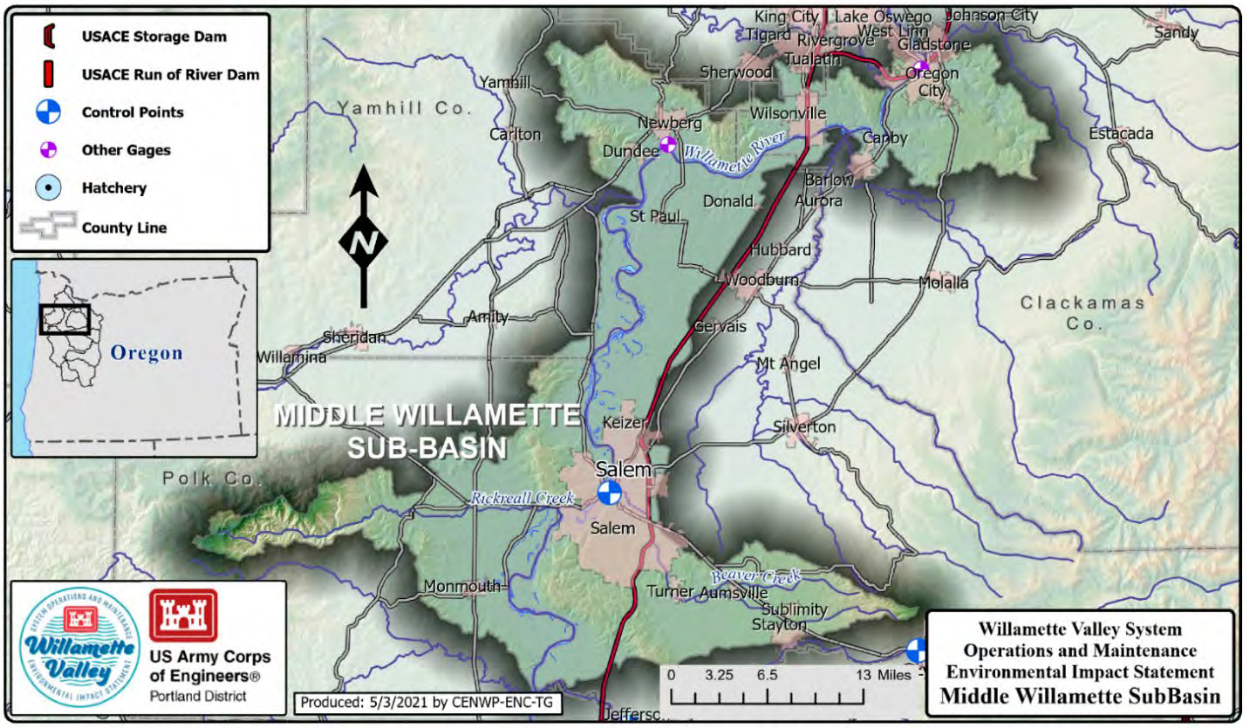



**Figure 3.2-10. Middle Willamette Basin subbasin**

Major population centers downstream of Salem include Newberg, Wilsonville, Canby, Oregon City, and Portland. The percentage of developed area in this reach of the Willamette is much greater than the other reaches. This most downstream control point for WVS is at Salem (USGS gage 14191000) and all projects affect flows at this location. The total drainage area of the Middle Willamette (including inflows from Yamhill, Tualatin, Molalla-Pudding Basins) makes up about 27 percent of the WRB.

The upper Willamette mainstem reach (Figure 3.2-11) flows north from just south of Eugene in a braided meandering channel to the Santiam River confluence. The floodplain in this approximately 130-mile reach is flat and wide. This reach was shaped through natural patterns of erosion and avulsion (abandonment of an existing channel and formation of a new one) as the Willamette River wandered laterally in a swath two to three miles wide. Many secondary channels, dead-end sloughs, and oxbow lakes remain as a result. Development activity near the river, mainly for agriculture and city growth, compelled the disconnection of the Willamette River from its floodplain by cutting it off from these secondary channels. The historic wandering of the Willamette River is now prevented with the application of levees and bank revetments.

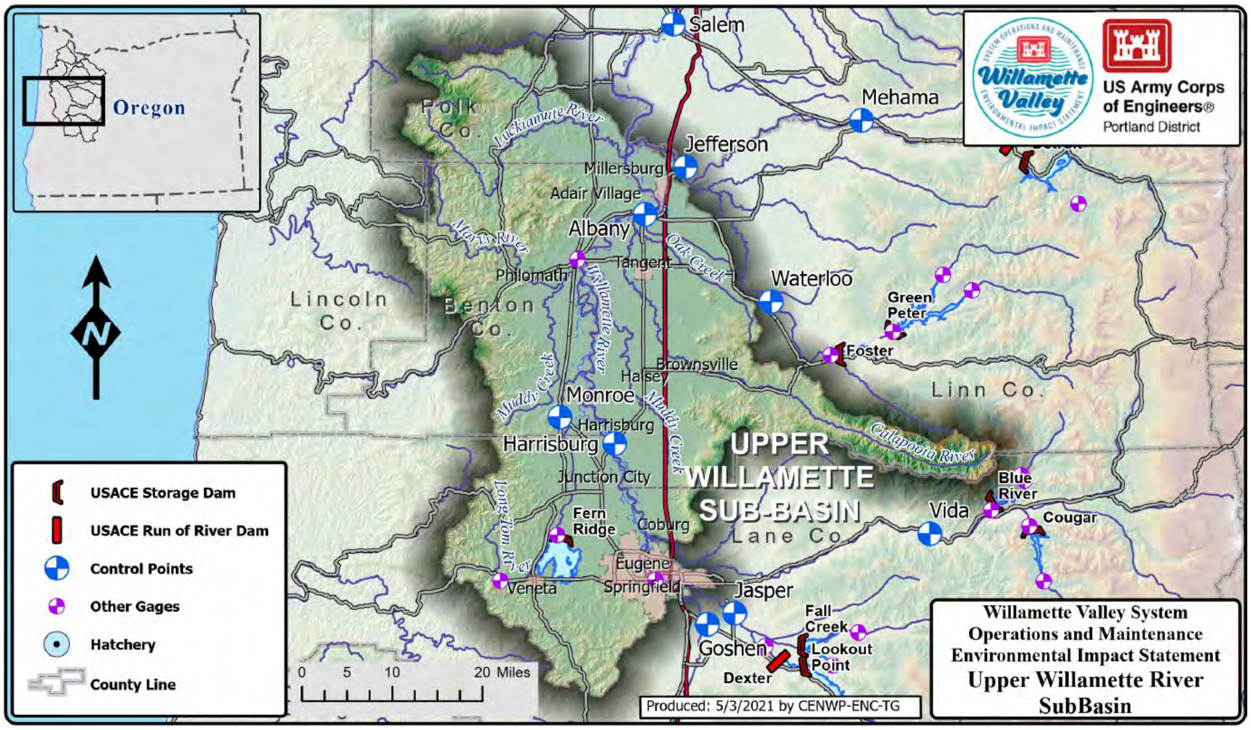



**Figure 3.2-11. Upper Willamette Basin subbasin**

Major population centers along the mainstem Willamette include Eugene-Springfield, Harrisburg, Corvallis, and Albany. Areas within the urban growth boundaries (UGB) of these cities are primarily developed. Outside the UGBs, the land is primarily used for agricultural purposes and state and national forests fringe the valley. The two control points in this reach are at Harrisburg (USGS gage 14166000) and Albany (USGS gage 14174000). As they are upstream of the Santiam confluence, the Santiam Basin WVS are not able to affect flows at these locations. This reach, west-to east from the Coast Range to the Cascade Range and south-to-north from Eugene to the Santiam River, encompasses approximately 16 percent of the WRB, including the Long Tom River.

#### *3.2.1.5.5 Santiam Basin*

The Santiam River subbasin has a drainage area of approximately 1,827 square miles, or about 16 percent of the entire WRB, divided between the North (Figure 3.2-12) and South (Figure 3.2-13) Santiam Rivers. Santiam River subbasin elevations range between 200 and 10,495 feet and average 2,040 feet msl. The Middle and South Santiam Rivers meet in Foster reservoir and the South Santiam River flows north to near Jefferson where it joins the North Santiam River. The North and South Santiam River form the mainstem Santiam River 11.7 miles upstream from the confluence of the Santiam and Willamette Rivers.

The North Santiam River is about 92 miles long and drains an area of approximately 655 square miles. The subbasin features heavily forested watersheds and high plateaus containing scattered volcanic peaks and rugged slopes. The Middle Santiam River also flows through steep, heavily forested mountain terrain, draining an area of 287 square miles. Stream gradients upstream of Green Peter Dam are exceptionally steep, dropping several hundred feet per mile in places. The South Santiam River, roughly 66 miles long, drains an area of approximately 1,040 square miles in geologically older terrain. The South and Middle Santiam Rivers join within Foster reservoir.

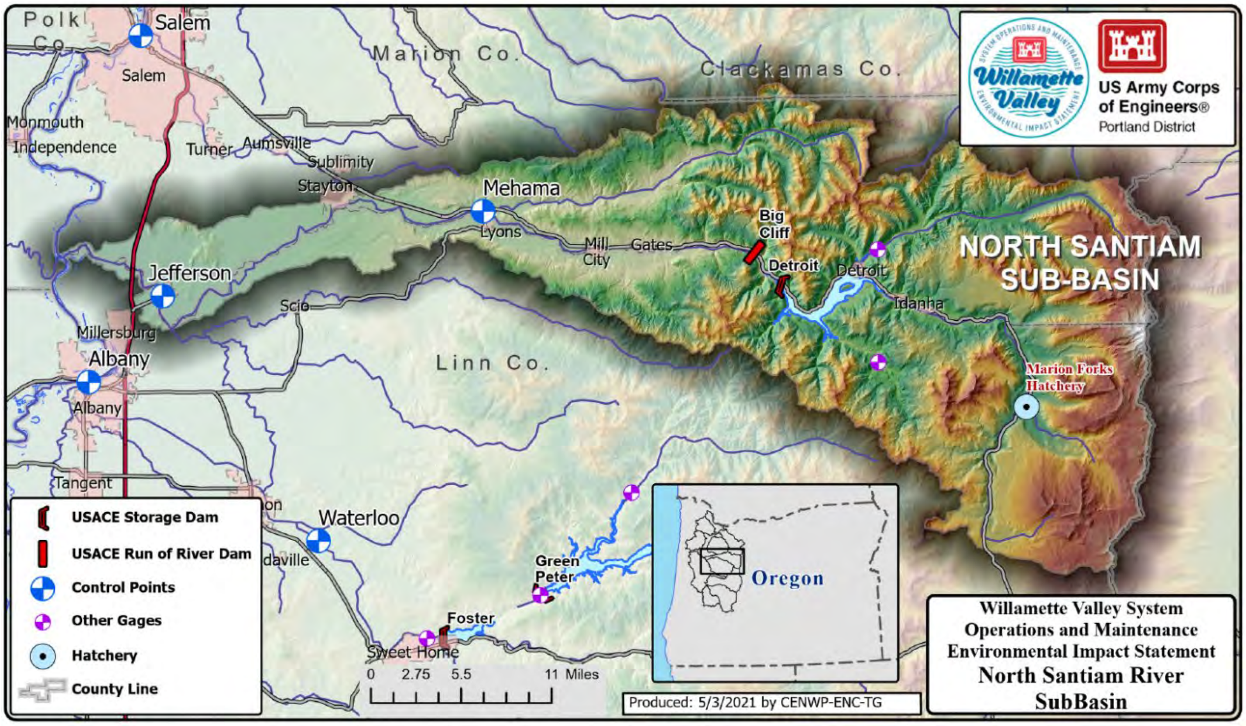



**Figure 3.2-12. North Santiam River subbasin**

There are two USACE dams in the North Santiam Basin. Detroit is a 450-foot-high concrete gravity dam and main storage reservoir with a usable volume of 321 thousand acre-ft (Kaf) and total storage of 455.1 Kaf. Big Cliff is the 172-foot-high reregulating dam directly downstream of Detroit. This enables Detroit to supply power at peak times and not cut off flow to the North Santiam River downstream. In other words, the Big Cliff pool elevation varies throughout the day as it supplies a constant daily flow and Detroit switches on and off. Total storage at Big Cliff is 6.5 Kaf. Both Detroit and Big Cliff have powerhouses rated at 100 MW and 18 MW, respectively (USACE 2015a).

The control points downstream of Detroit and Big Cliff are the North Santiam at Mehama (USGS gage 14183000) and the Santiam at Jefferson (UGSG gage 14189000) on the mainstem, which they share with the South Santiam WVS.


**Figure 3.2-13. South Santiam River subbasin**

There are two USACE dams in the South Santiam Basin, Foster and Green Peter. Green Peter impounds the Middle Santiam and receives a greater share of the total flow, as compared to the South Santiam above Foster. Green Peter is a 327-foot-high concrete gravity dam and has usable storage of 312.5 Kaf and total volume of 430 Kaf. Foster is a rock fill dam, 126 feet high, with usable storage of 28.3 Kaf and total storage of 60.7 Kaf. Foster reregulates Green Peter, but also has some flood storage of its own. Green Peter and Foster have powerhouses rated at 80 MW and 20 MW, respectively (USACE 2015a).

The control points downstream of Foster and Green Peter are the South Santiam at Waterloo (USGS gage 14187500) and the Santiam at Jefferson (UGSG gage 14189000) on the mainstem, which they share with the North Santiam WVS.

#### *3.2.1.5.6 Long Tom Subbasin*

The Long Tom River and Coyote Creek are the two principal rivers entering Fern Ridge Lake, with a combined drainage area of about 2 percent of the entire WRB. A portion of Amazon Creek in Eugene is also diverted into the lake, thus adding an additional 23 square miles to the lake's drainage area.

The Long Tom Basin (Figure 3.2-14) is relatively low, with a maximum elevation of 2,125 feet. Mean elevation of the Fern Ridge's entire subbasin, including the Amazon Creek drainage, is 670 feet and 99 percent of the entire subbasin is below 1,500 feet.

Below Fern Ridge Dam, the Long Tom River meanders for 24 miles before joining the mainstem Willamette River north of Monroe, Fern Ridge's control point (USGS gage 14170000). Portions of the Long Tom River are channelized with embankments to increase the maximum allowable release from Fern Ridge. Three smaller streams, Amazon, Bear, and Ferguson join the Long Tom River between the dam and the Long Tom-mainstem Willamette River confluence.

Fern Ridge Dam is an earth-fill dam with a concrete outlet works. It is 49 feet high with usable storage is 101.1 Kaf and total capacity of 101.2 Kaf. The lake is much shallower than the other WVS reservoirs and evaporation is a significant factor. Fern Ridge does not have a powerhouse (USACE 2015a).

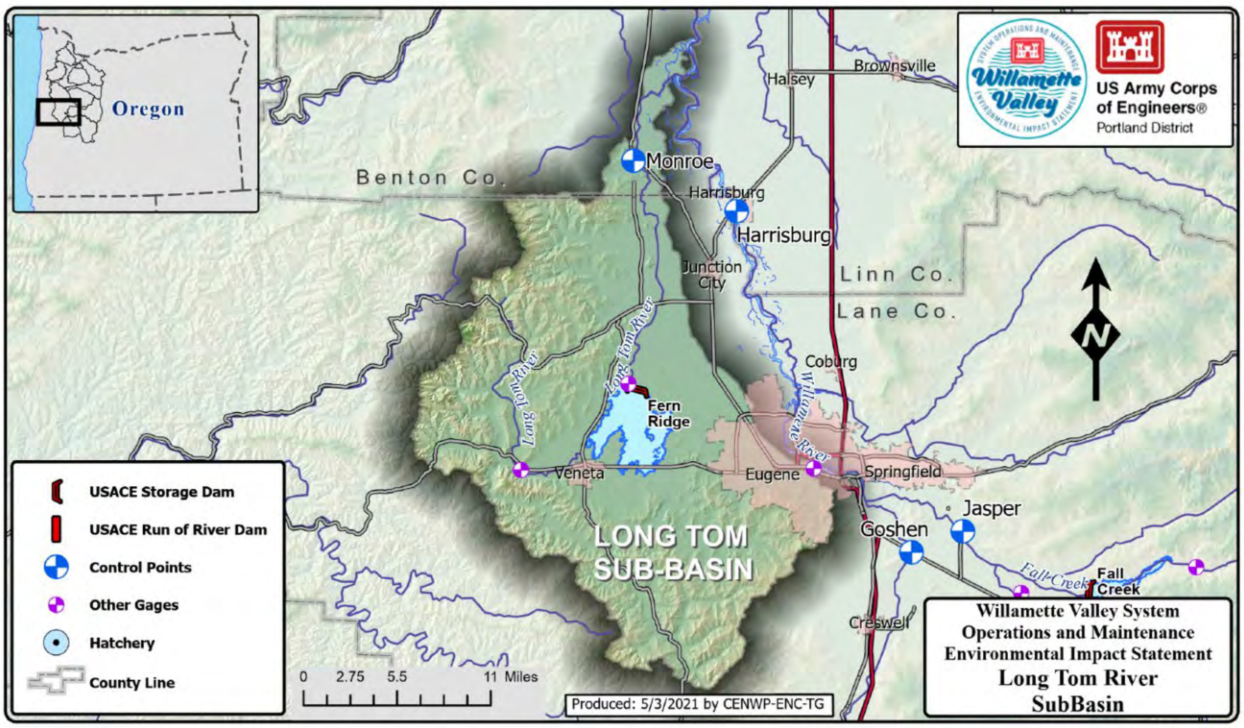



**Figure 3.2-14. Long Tom River subbasin**

### *3.2.1.5.7 McKenzie Subbasin*

The McKenzie subbasin has a drainage area of approximately 1,300 square miles, or about 12 percent of the entire WRB (Figure 3.2-15). The McKenzie River is roughly 90 miles long, joining the mainstem Willamette River a few miles north of Eugene. Elevations range from 350 feet to 6,650 feet. The highest elevations in the headwaters are rugged and heavily forested. There are two non-federal projects in the McKenzie River basin: Carmen-Smith Hydroelectric Project in the upper McKenzie River and Leaburg-Walterville Hydroelectric Project in the lower McKenzie River.

Blue River Dam is on the Blue River about 2 miles upstream of its confluence with the McKenzie River, near Blue River, Oregon. It is a 270-foot-high earth fill dam, with a usable storage of 82.8 Kaf and total storage of 89.5 Kaf. Blue River does not have a powerhouse. Cougar impounds the

South Fork of the McKenzie River, which joins the mainstem McKenzie about 3 miles upstream of the Blue River confluence. The earth-fill dam is 452 feet high and has an installed power capacity of 25 MW. A WTC tower was constructed in 2005, enabling water to be withdrawn from a greater variety of depths in the reservoir. The usable storage capacity is 165.1 Kaf and total storage is 219.3 Kaf (USACE 2015a). Mean basin elevations above Blue River and Cougar are higher than 3,500 feet and both dams control more than 95 percent of their respective watersheds.

Blue River and Cougar share a control point on the McKenzie River at Vida (USGS gage 14162500). Further downstream, the first common control point with WVS outside the subbasin is on the mainstem Willamette at Harrisburg (USGS gage 14166000).

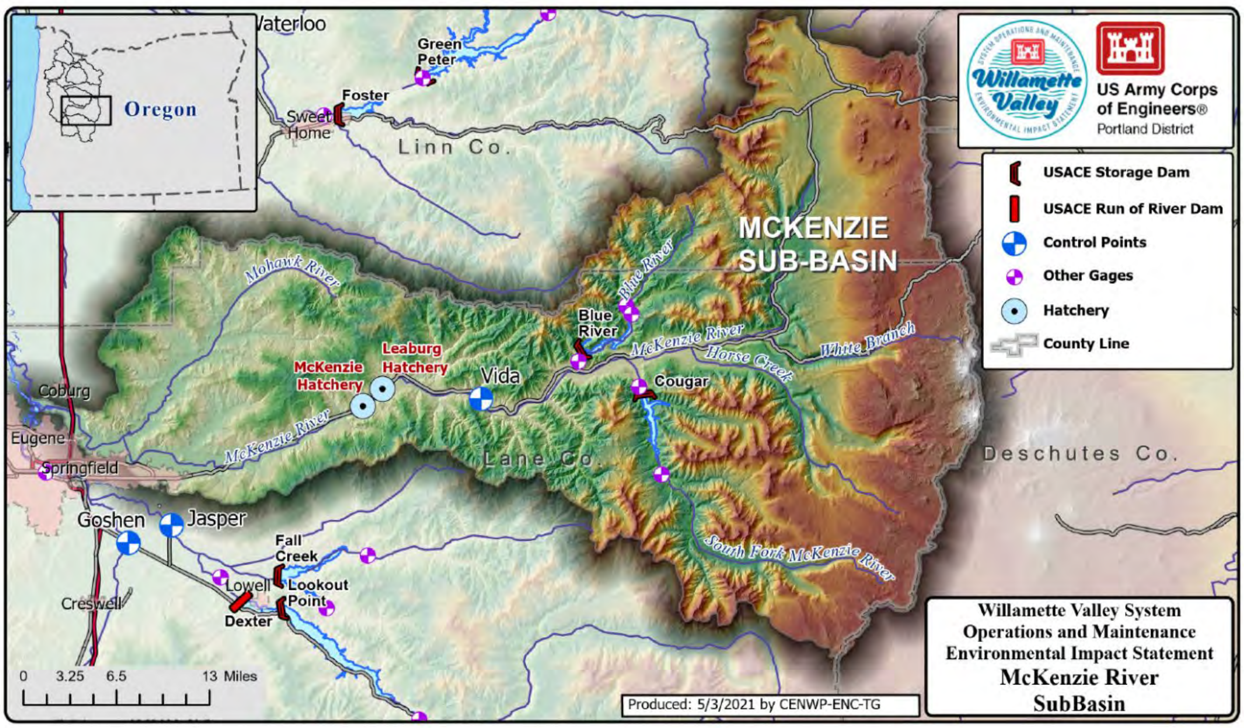



**Figure 3.2-15. McKenzie River subbasin**

### *3.2.1.5.8 Middle Fork of the Willamette Subbasin*

The Middle Fork of the Willamette subbasin (Figure 3.2-16) has a drainage area of approximately 1,569 square miles, or about 14 percent of the entire WRB, ranging from 450 feet at Eugene to 8,790 feet at Diamond Peak, located on the eastern boundary of the subbasin. Most of the subbasin is within the Willamette and Umpqua National Forests.

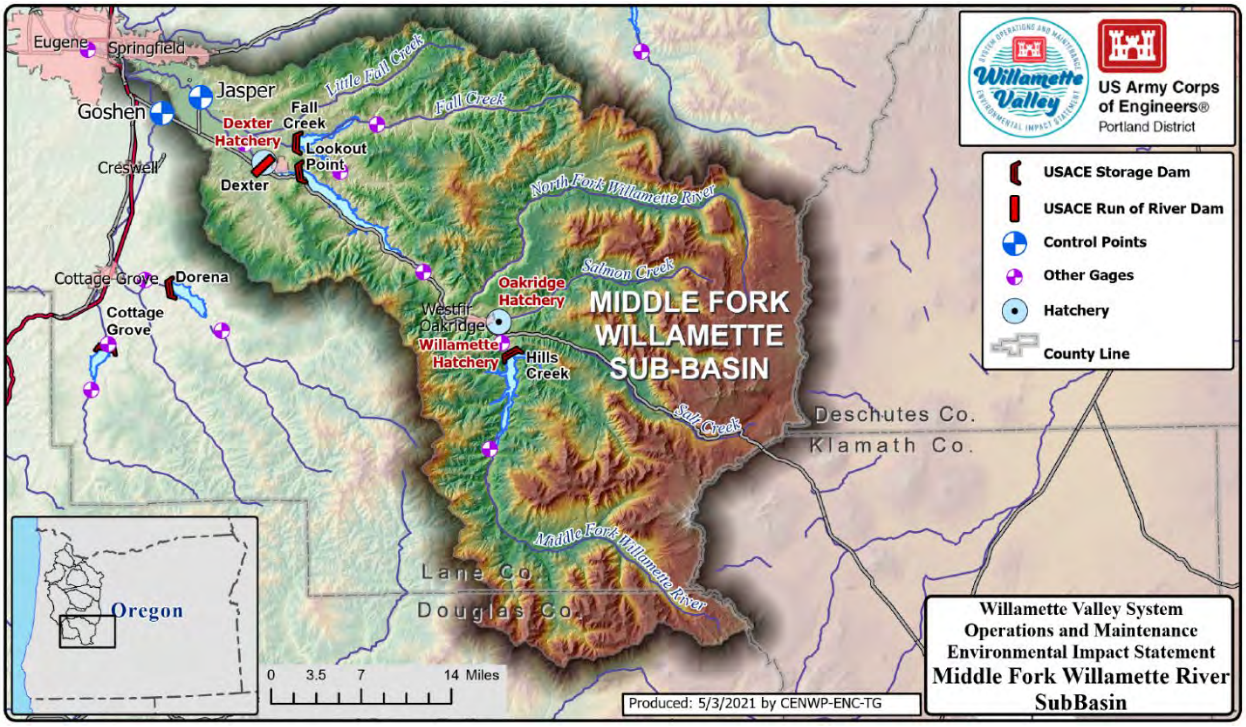



**Figure 3.2-16. Middle Fork of the Willamette River subbasin**

Water originating from the headwaters of the Middle Fork pass through three reservoirs before Eugene, in Hills Creek, Lookout Point and Dexter. Salt Creek, Salmon Creek and the North Fork of the Willamette River also join the Middle Fork between Hills Creek and Lookout Point. Downstream of Lookout Point, Dexter reregulates Lookout Point to enable power peaking operations. Fall Creek Dam impounds Fall Creek and Winberry Creek. The confluence between Fall Creek and the Middle Fork is about 2 miles east of Jasper and 6 miles west of Lowell, on the northern bank of Dexter reservoir.

Hills Creek is a 304-foot-high earth and gravel fill embankment dam. The usable storage of the reservoir is 234.3 Kaf and total storage is 356 Kaf. Lookout Point is a 246-foot-high earth fill dam with concrete outlet works flowing directly into Dexter reservoir. The usable storage is 336.4 Kaf and total storage is 455.8 Kaf. The earth-fill Dexter dam is much smaller, with a total storage capacity of 27.5 Kaf. Hills Creek, Lookout Point and Dexter have powerhouse capacities of 30 MW, 120 MW and 15 MW, respectively. Fall Creek does not have power generating capacity (USACE 2015a).

The shared control point for all four WVS projects in the Middle Fork basin is at Jasper (USGS gage 14152000). The Middle and Coast Forks join to become the mainstem Willamette River south of Springfield. Further downstream, the first common control point with WVS outside the subbasin is on the mainstem Willamette at Harrisburg (USGS gage 14166000).

### *3.2.1.5.9 Coast Fork of the Willamette Subbasin*

The Coast Fork of Willamette (Figure 3.2-17) has a drainage area of 669 square miles, or about 6 percent of the entire WRB. Elevations in the Coast Fork drainage subbasin range from about 450 at Eugene to 6,000 feet at the headwaters. The drainage headwaters consist largely of steep, rugged, mountainous terrain dissected by narrow river valleys. Much of the land is heavily forested. Downstream of Cottage Grove, the Coast Fork runs through a relatively wide and flat river valley, before becoming confined by the hills south of Eugene just upstream of the confluence with the Middle Fork. The Coast Fork subbasin is lower in elevation than the other Willamette headwater basins and so contributes less flow as compared to its drainage area.

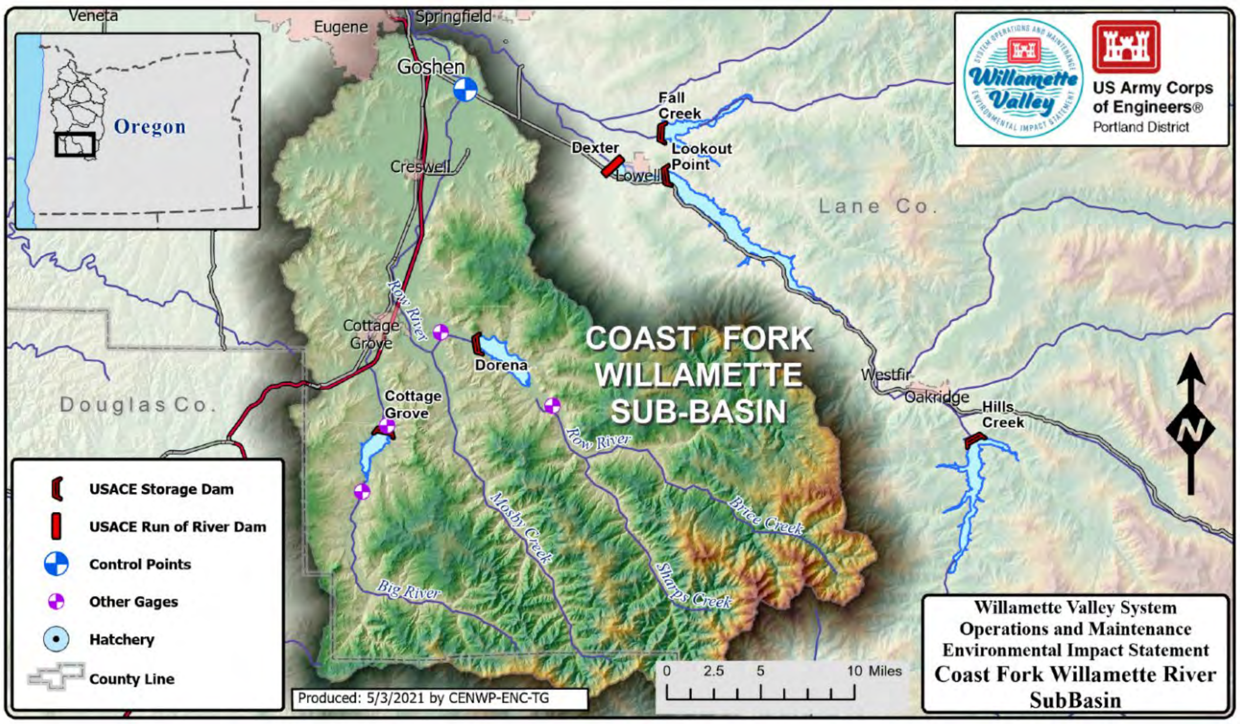



**Figure 3.2-17. Coast Fork Willamette River subbasin**

Cottage Grove and Dorena are the WVS dams on the Coast Fork and Row Rivers, respectively. Both dams are earth fill with concrete outlet works. Dorena is the larger of the two, with a height of 145 feet, usable storage capacity of 72.1 Kaf and total capacity of 77.6 Kaf, compared with Cottage Grove at 114 feet high and usable and total capacities at 31.8 and 33.5 Kaf. Dorena hosts a non-federal powerhouse with a capacity of 7.5 MW and Cottage Grove does not have generating capacity (USACE 2015a).

Cottage Grove and Dorena share a control point on the Coast Fork at Goshen (USGS gage 14157500). The Coast and Middle Forks join to become the mainstem Willamette River south of Springfield. Further downstream, the first common control point with WVS outside the subbasin is on the mainstem Willamette at Harrisburg (USGS gage 14166000).

### 3.2.2 Environmental Consequences

#### *3.2.2.1 Methodology*

USACE and others commonly use the term hydrology and hydraulics (H&H) to discuss the quantity, movement, or behavior of water. The WVS PEIS models the NAA and seven action alternatives over the observed period of record to show how water would move through the system, both within and downstream of the WVS dams and reservoirs, given a specific set of operational measures. Since hydrologic processes describes the flow of water through the system, only measures that would affect the volume or timing of flow are analyzed in this section. For example, structural measures that alter the water temperature would not affect hydrologic processes overall, and therefore, are not included in this analysis.

##### *3.2.2.1.1 Reservoir Operations Model*

The primary method to model basin flow and WVS reservoir operations for the PEIS is the Hydrologic Engineering Center Reservoir Simulation System (HEC-ResSim). ResSim simulates reservoir operations for flood management, low flow augmentation and water supply for planning studies, detailed reservoir regulation plan investigations, and real-time decision support. The input flow data, both for inflows to the reservoirs and flows from river systems downstream, are daily average flow for the period of record (1935 to 2019). This dataset is an extended version of the Willamette Flood Insurance Study (USACE 2011a; USACE 2013a) and 2010 Level Modified Streamflows (BPA 2011). Appendix B, Hydrologic Processes Technical Information, has additional information on the development of the hydrologic dataset. The outputs for each alternative are compared to the NAA to determine the alternative's effect on the system. The details of the flows modeled by ResSim model are also taken for analysis and use by other technical teams.

The period of record analysis provides a wide range of historical meteorological variability. The ResSim model can use the flow information to show how the system operates with a variety of goals across a long period. The longer period enables the model to compute probability based on the historical record. For example, the model can estimate the chance in any given year that a reservoir will fill to capacity during the spring or exhaust the available stored water prior the major flood season. The period of record analysis also allows USACE to study how the system behaves under conditions that did not exist, like running inflows from before the WVS dams were constructed.

A computer reservoir regulation model, such as ResSim, requires fixed operational scenarios, or rules, tested over many years of data. Each alternative alters the rule set to show differences in operation under the same inputs – the flow data – without human interference or preferences. Real-world reservoir operation is complex: different information is available to the water manager for decision making, and decisions are shaped by an individual water manager's experience and risk tolerance. Water managers also adapt operations as is possible within constraints to meet goals responding to the unique conditions of a specific water year. Operational changes of this nature to match the observed record are not possible nor desirable to represent in a planning model like the

PEIS. They would make comparing different alternatives substantially more challenging and likely skew the results towards the actions already undertaken in real-world reservoir operations.

##### *3.2.2.1.2 Presentation of Results*

Summary hydrographs are produced to describe the changes to the flow and water surface elevation with the implementation in each of the alternatives. A hydrograph is a chart showing an indicator of water flow (such as stage or discharge) over time, typically over a water year. A summary hydrograph is an especially useful way to display information because it shows the expected range and likelihood of water levels (or flow) at a given location for each day of the water year. The curves on a summary hydrograph do not represent a single water year. Rather, each curve represents the percentage chance of not exceeding the corresponding water level (or flow) on a given day. Five non-exceedance levels are shown: 5, 25, 50, 75 and 95 percent, representing the percentile (P##) of data below the line. In Figure 3.2-18, the color series for one alternative is compared against the base greyscale background to show differences between the presented alternative and the NAA. For example, the 25 percent curve on the summary hydrograph of reservoir elevation is about 1500 feet on April 1 as in the chart, which means there is 75 percent chance the water surface elevation would be above 1500 feet and a 25 percent chance it would be below 1500 feet on April 1 across all water years. Only selected charts are presented in the narrative analysis of this section. A complete set of charts across all WVS dams and reservoirs and control points is available in Appendix B, Hydrologic Processes Technical Information.

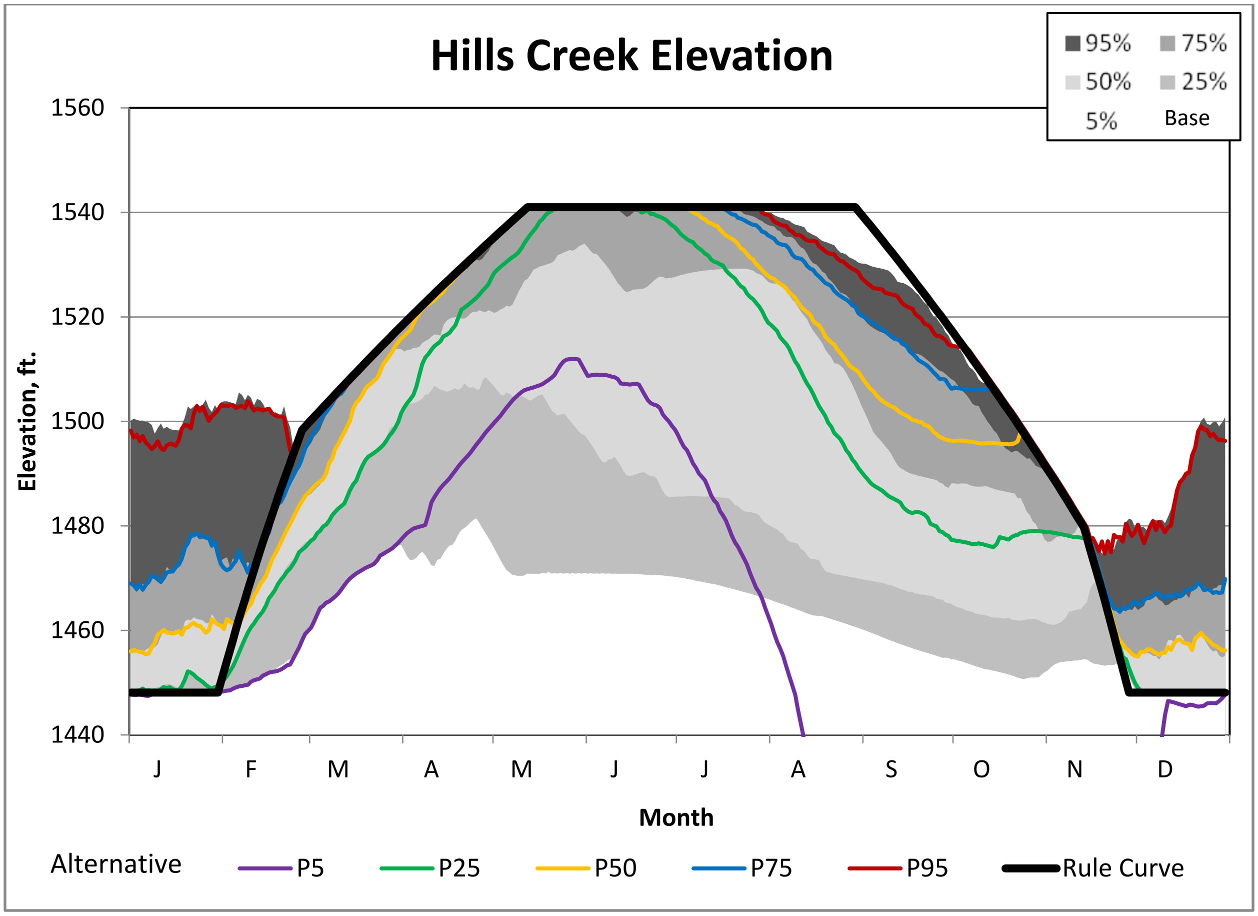



**Figure 3.2-18. Example of non-exceedance chart at Hill Creek Reservoir**

Certain other reservoir operational constraints can also limit the level of the drawdowns in each year. Apart from high inflow, the primary limiter of the drawdowns in the WVS reservoirs is the general drafting guideline of no more than 3 feet of water surface elevation per day. This guideline is used during non-emergency situations to reduce the probability of landslides around the reservoir rim, upstream embankment settlement, and slope stability issues. In practice, this draft limit would cause the reservoir to be above the drawdown target elevation for extended periods as both the reservoir water surface elevation and the target descend at the same 3 ft/day. Figure 3.2-19 shows the fall reservoir drawdown at Green Peter with average reservoir elevation across all years (P50 line) and the year 1993 as an example year, where the reservoir moved parallel to the target for several months. While there would be enough outlet capacity to quickly reach the target, the drafting limit of 3 ft/day prevents achieving the target elevation more quickly. More broadly, this shows an instance where operating a reservoir is a matter of competing goals and a specific target may not always be possible due to other constraints within the reservoir or larger WVS.

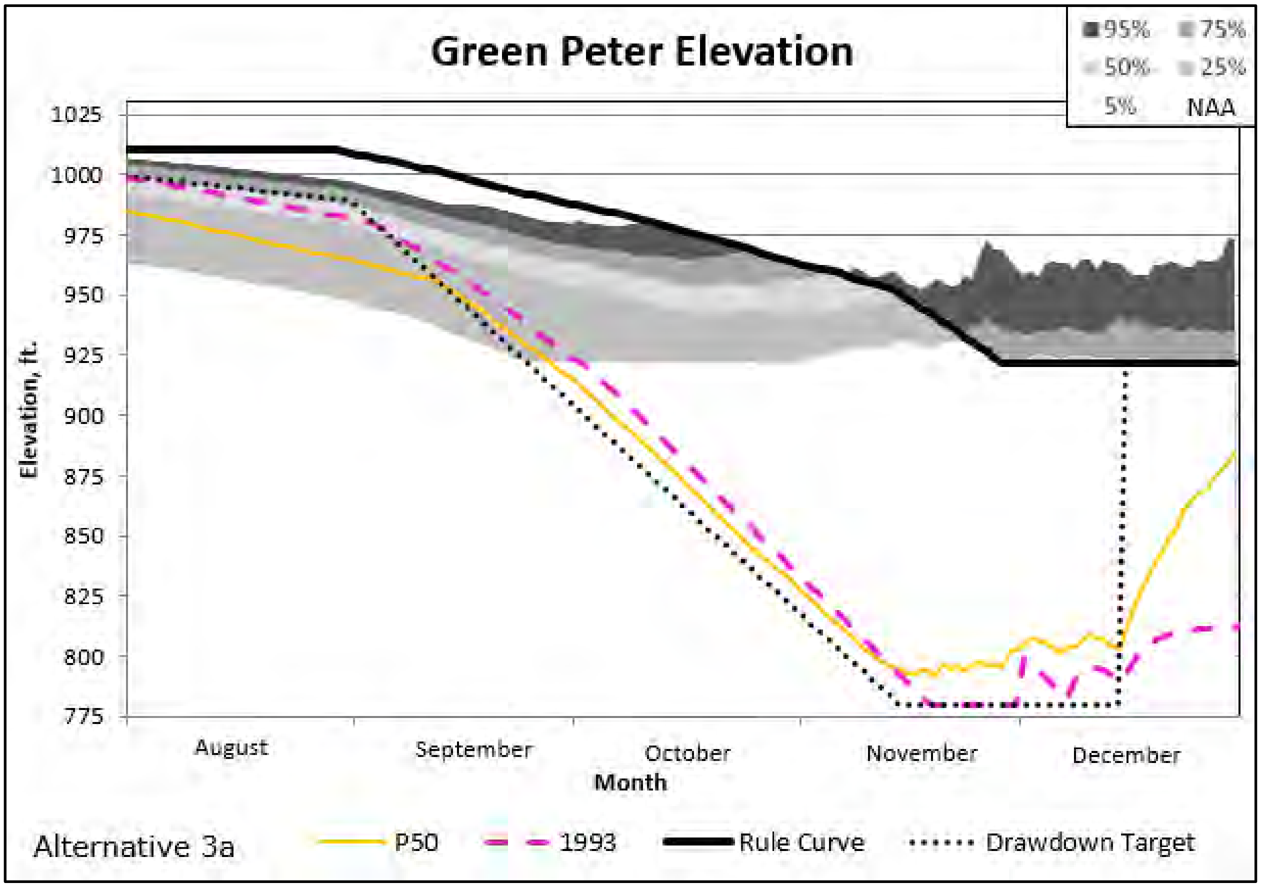



**Figure 3.2-19. Alternative 3A Green Peter reservoir drawdown with the year 1993 as an example of drafting limits preventing the reservoir from reaching the target elevation.**

*3.2.2.1.3 Flood Risk Management*

Across all alternatives, USACE used a screening criterion of "No Increase in Flood Risk" to exclude measures with the potential to increase flood risk during the development phase of the WVS PEIS. Specifically, these are measures that increase the frequency, duration, or magnitude of flow at control points during flood season above threshold stages along tributaries and the mainstem of the Willamette River, increasing flood risk. Operations that increase flood risk can include increased maximum releases from WVS dams or reduced flood storage, leading to higher pool elevations and higher releases to mitigate the risk of overtopping. For the WVS PEIS, operations that increase maximum releases or reduce seasonal flood storage were removed from consideration. Refer to Appendix B for additional discussion on these operations.

*3.2.2.1.4 Evaluation Criteria*

Table 3.2-1 explains the hydrologic criteria for potential effects across the WRB for the alternatives.

**Table 3.2-1. Evaluation Criteria for Potential Hydrologic Effects**

| Effect Scale | Criteria |
|---|---|
| None/negligible | Willamette Basin regulated hydrology would not be changed, would be nondetectable, or changes to water level, discharge, volume, or timing would be slight and localized. The area extent of effects would be small (limited) and would not require additional consideration or adaptive management. |
| Minor | Changes to the Willamette Basin regulated hydrology would be measurable, although the change in water level, discharge, volume, or timing would be small and localized at the watershed level. The need for adaptive management measures would be evaluated to reduce or minimize any potential changes. |
| Moderate | Changes to the Willamette Basin regulated hydrology would be measurable and have either sub-basin or basin-wide differences in water surface elevation, discharge, volume, or timing. The regulated hydrology would be within current regulatory standards[1], but potentially differ from historic condition. The need for adaptive management or mitigation measures would be evaluated and would likely be able to reduce the magnitude of potential changes. |
| Major | Changes to the Willamette Basin regulated hydrology would be readily measurable and would have substantial differences in water level, discharge, volume, or timing on a regional level. The regulated hydrology may not meet existing regulatory standards[1]. The need for adaptive management and mitigation measures would be evaluated to reduce changes in the system, though hydrologic changes would be expected regardless of the actions implemented. |

[1] Applicable regulatory standards can include minimum target flows that the WVS intends to exceed, flow ramping rate limitations (how fast the flow can change in a given time period) and maximum flowrate at a given point (flood operations or physical limits).

The effects in the hydrologic processes are inherently long-term as they would last for the duration of the project (2050) and potentially have lasting effects beyond the project. The WVS dams and reservoirs alter the hydrology of the WRB and the imposed hydrology will continue to affect lasting change on many other areas discussed in this PEIS. Since all WVS regulation actions discussed across all alternatives would be long-term for hydrologic processes, duration is not evaluated or discussed further in this section. These effects are determined by comparing to the NAA throughout these sections unless specifically call out.

Hydrologic effects are evaluated with an integrated reservoir regulation model. The extent of every alternative is basin-wide, or regional. For example, even a seemingly small change to water storage at one reservoir can and does alter the operation of any other, or several reservoirs, within the WRB. While dams and reservoirs closer to each other are more likely to affect each other's operations, shared river control points and flow targets require that the

WVS dams and reservoirs operate together. Since all WVS regulation actions discussed across all alternatives would be regional for hydrologic processes, extents are not evaluated or discussed further in this section.

The changes to hydrologic processes are not characterized in this PEIS as adverse or beneficial. Such a determination would be arbitrary without some other criteria to judge the changes in hydrologic processes, such as fish survival or recreation. Furthermore, some potential changes to hydrologic processes could reasonably be both adverse and beneficial depending on the criteria and perspective applied. Since the results of hydrologic processes are some of the inputs to the other analysis in this PEIS, the determination of adverse or beneficial effects is properly placed within each of those effects analyses.

###### *3.2.2.1.5 Construction Effects on Hydrologic Processes*

This PEIS discusses general, qualitative effects from construction at the programmatic level. Site-specific project details for each construction measure will be determined during the implementation phase. Subsequent tiered NEPA documents would discuss detailed site-specific effects during the implementation phase. Most of the construction activities associated with the measures within each alternative would only locally affect the hydrology of the river reaches, with the notable exception of the construction of WTC towers. For example, water routed through a different outlet for construction activities at a fish facility would alter the reservoir regulation outlet choice, but not the total flow out of the dam.

Depending on construction methods, construction of the WTC towers at Detroit, Lookout Point, Green Peter, and Hills Creek may require reservoir drawdowns and pool restrictions over several years. A long drawdown may also be necessary at Cougar to construct the outlet works for the routine use of the diversion tunnel. If there are drawdowns in the site-specific plans, water would be drafted out of the reservoir prior to construction, increasing the instream flow downstream of the reservoir until it reaches the necessary elevation. During the construction activities, a lower pool at each of these reservoirs would mean notably reduced conservation season water storage. This could also impact other reservoirs, lowering their stored water volume as they release more water to meet shared downstream flow targets, potentially inducing systemwide effects for construction at selected locations. In the winter, each reservoir could be subject to pool restrictions over the construction period, which may impact FRM operations.

Since the timing, duration, and extent of non-routine major maintenance are unforeseeable (Section 1.8.2, Operation, Maintenance, Repair, Replacement and Rehabilitation), the hydrologic effects of those actions are unforeseeable as well. The hydrologic effects for these actions, along with all other types of effects, would be the subject of additional analysis under the tiered NEPA process described in Chapter 7.

#### *3.2.2.1.6 Climate Change*

Appendix F1, Willamette Basin Climate Change Qualitative Assessment, and Appendix F2, Supplemental Climate Change Information, describe projected climate change trends likely to be experienced in the WVS. The supplemental appendix also identifies changing climate factors and hydrology that could have a consequential impact to the PEIS resource areas. The climate change factors most important to the hydrologic processes are projected future changes in precipitation (rainfall and snow), changing rates in peak and average streamflow, change in snowpack and flow volumes. These climate change factors are described in the technical appendices and USACE qualitatively assesses the expected effects to the system under NAA and each alternative.

USACE expects climate change to impact the WVS in several ways. Temperatures in the WRB are expected to warm relative to the historic period 1970-1999 by another 1.5 to 3°F by about mid-century and 2 to 5°F by end-of-century. Winter snowpack is likely to decline over time as more winter precipitation falls as rain instead of snow. Future precipitation is projected to trend upward for the rest of the century, particularly in the winter and early spring. Later spring months become drier, effectively starting already dry summers earlier. Decreasing baseflow could become drier, primarily further reducing summer flow. USACE used these impacts to qualitatively assess expected changes to reservoir storage and flow, mapped onto the operations each alternative would implement.

### ***3.2.2.2 Environmental Consequences Summary***

The NAA would represent the current management direction of the WVS and as described in Section 2.4.1, No Action Alternative. Each of the action alternatives would change the seasonal flow and use of stored water in the system. In comparison to the NAA, Alternatives 1 and 4 would store more water in the spring and release it during the summer and fall, though how flow is stored and released is different between Alternatives 1 and 4. Alternatives 2A and 2B would store somewhat less water for release in the summer and fall, while incorporating selected drawdowns. Alternatives 3A and 3B include spring reservoir drawdowns at different selected projects and deeper fall reservoir drawdowns at WVS reservoirs in the Santiam, McKenzie, and Middle Fork subbasins – excluding Foster and the reregulating dams. Alternative 5 would be similar to Alternative 2B but release more water in the spring of dry years.

See Tables 3.2-2 to 3.2-7 for a summary of hydrologic effects organized by location across the WRB. All elevations in the hydrologic processes Environmental Consequences are in USACE WVS project datums unless otherwise noted.

**Table 3.2-2. Santiam Subbasin Summary of Hydrologic Processes Environmental Consequences (bolded text represents most substantial changes from NAA)**

| Location | No Action Alternative | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| Detroit Reservoir[1] | Would reach 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. | Would reach top of conservation storage **more** than 75% of years during the spring and **would very rarely reach** bottom of conservation storage in the fall. Winter operations are similar to the NAA. | Would reach top of conservation storage **about 75%** of years during the spring and **would very rarely reach** bottom of conservation storage in the fall. | Would reach top of conservation storage **about 75%** of years during the spring and **would very rarely reach** bottom of conservation storage in the fall. | Would **never** reach the top of conservation storage and would reach **lower minimum elevation 75% of years. Increased winter storage space** from deeper fall reservoir drawdown. | Would reach top of conservation storage **about 75%** of years during the spring and **would very rarely reach** bottom of conservation storage prior to deeper fall reservoir drawdown. **Increased winter storage space** from deeper fall reservoir drawdown. | Would reach top of conservation storage **about 75%** of years during the spring and **would very rarely reach** bottom of conservation storage in the fall. | Would reach top of conservation storage **about 75%** of years during the spring and **would very rarely reach** bottom of conservation storage in the fall. |
| Detroit/ Big Cliff Outflow | Would meet or exceed outflow targets between 1,000 and 1,500 cfs except in fall of very dry years. | Would meet or exceed outflow target of **1,050 cfs in nearly all years.** | Would meet or exceed outflow target of between **1,000 and 1,600 cfs in nearly all years.** | Would meet or exceed outflow target of between **1,000 and 1,600 cfs in nearly all years.** | **Would increase spring flow**. Would meet outflow target between **1,000 and 1,600 cfs in only 25% of wettest years**; minimum flow of about **400** | Would meet or exceed outflow target of between **1,000 and 1,600 cfs** except in **November** of very dry years. | Would meet or exceed outflow target of between **1,000 and 1,600 cfs in nearly all years.** | Would meet or exceed outflow target of between **1,050 and 1,600 cfs in nearly all years.** |

| Location | No Action Alternative | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| | | | | | **cfs in dry years.** | | | |
| North Santiam at Mehama | Flow would vary with BiOp targets, falling to about 700 cfs in fall of very dry years. | **Steadier** flow with Congress-ionally authorized minimum flow targets, falling to about **950 cfs** in fall of very dry years. | Lower varied spring flow and similar summer flow across all years. About **1,000 cfs** in fall of very dry years. | Lower varied spring flow and similar summer flow across all years. About **1,000 cfs** in fall of very dry years. | Higher spring flow. Only wettest years would approach NAA flows in summer with about **400 cfs** in fall of very dry years. | Lower varied spring flow and higher summer flow across all years. About **1,000 cfs** in fall of very dry years. | Lower varied spring flow and similar summer flow across all years. About **1,000 cfs** in fall of very dry years. | Lower varied spring flow and similar summer flow across all years. About **1,000 cfs** in fall of very dry years. |
| Green Peter Reservoir[2] | Would reach 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. | Would reach top of conservation storage **more than 90%** of years during the spring and **would very rarely reach** bottom of conservation in the fall. Winter operations similar to the NAA. | Would reach top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years prior the deeper fall reservoir drawdown. Would **increase winter storage space** from deeper fall reservoir drawdown. | Would reach top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years prior the deeper fall reservoir drawdown. Would **increase winter storage space** from deeper fall reservoir drawdown. | Would reach top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years prior the deeper fall reservoir drawdown. Would **increase winter storage space** from deeper fall reservoir drawdown. | Would **never** reach the top of conservation storage and reaches **lower minimum elevation about 70% of years.** Would **increase winter storage space** from deeper fall reservoir drawdown. | Would reach top of conservation storage less than 75% of years during the spring and the **lower minimum elevation** in about 5% of years in late fall. Winter operations similar to the NAA. | Would reach top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years prior the deeper fall reservoir drawdown. Would **increase winter storage space** from deeper fall reservoir drawdown. |

| Location | No Action Alternative | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| Foster Reservoir[3] | Would only vary from rule curve during flood operations. | Would only vary from rule curve during flood operations. | Would only vary from rule curve during flood operations. | Would only vary from rule curve during flood operations. | Would only vary from rule curve during flood operations. | **Would reach bottom of conservation** storage in summer during average and drier years. | Would only vary from rule curve during flood operations. | Would only vary from rule curve during flood operations. |
| Green Peter/ Foster Outflow | Would meet or exceed outflow targets between 800 and 1,500 cfs except in summer and fall of very dry years. | Would meet or exceed outflow target of **750 cfs in nearly all years.** | Would **increase fall flow.** Would meet or exceed outflow target of between **1,000 and 1,550 cfs** except in **November of very dry years**. | Would **increase fall flow.** Would meet or exceed outflow target of between **1,000 and 1,550 cfs** except in **November of very dry years**. | Would **increase fall flow.** Would meet or exceed outflow target of between **1,000 and 1,550 cfs** except in **November of very dry years**. | Would **increase spring flow.** Would only meet flow targets in very wet years. Average **summer flow about 600** cfs, and dry years **minimum flow about 110 cfs.** | Would meet or exceed outflow target of between **1,000 and 1,550 cfs** except in **November of very dry years.** | Would **increase fall flow.** Would meet or exceed outflow target of between **700 and 1,550 cfs** except in **November of very dry years**. |
| South Santiam at Waterloo | Flow would vary with BiOp targets, falling to about 550 cfs in fall of very dry years. | **Steadier** flow with Congress-ionally authorized minimum targets, falling to about **700 cfs** in fall of very dry years. | Lower varied spring flow and higher summer flow across all years. About **900 cfs** in very dry years. **Higher fall flows** due to drawdown. | Lower varied spring flow and higher summer flow across all years. About **900 cfs** in very dry years. **Higher fall flows** due to drawdown. | Lower varied spring flow and higher summer flow across all years. About **900 cfs** in very dry years. **Higher fall flows** due to drawdown. | Higher spring flow. Only wettest years approach NAA flow in summer with **minimum of about 100 cfs** in dry years. | Lower varied spring flow and higher summer flow across all years. About **900 cfs** in very dry years. | Lower varied spring flow and higher summer flow across all years. About **900 cfs** in very dry years. **Higher fall flows** due to drawdown. |
| Santiam at Jefferson | Flow would vary BiOp targets, falling to about 1200 cfs in summer | **Lower, steadier flow** across all years in spring and summer and higher | **Lower spring flow** in dry years. Higher summer flow across all years and much | **Lower spring flow** in dry years. Higher summer flow across all years and much | **More varied flow** from spring to fall. More flow during wet years and less | **Higher spring flow.** More summer flow during wet years and less during dry | **Lower spring flow** in dry years and higher summer and fall flow across all | **Lower spring flow** in dry years. Higher summer flow across all years and much |

| Location | No Action Alternative | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| | of very dry years. | flow in fall as reservoirs prepare for flood season. About 1200 cfs in very dry years. | higher fall flow during Green Peter drawdown. About **1,400 cfs** in very dry years. | higher fall flow during Green Peter drawdown. About **1,400 cfs** in very dry years. | flow during dry years. About **800 cfs** in very dry years. | years. About **700 cfs** in very dry years. | years. About **1,400 cfs** in very dry years. | higher fall flow during Green Peter drawdown. About **1,700 cfs** in very dry years. |

1. Detroit top and bottom of conservation storage are elevation 1563.5 and 1450 ft, respectively.

2. Green Peter top and bottom of conservation storage are elevation 1010 and 922 ft, respectively.

3. Foster top and bottom of conservation storage are elevation 637 and 613 ft, respectively.

**Table 3.2-3. Long Tom Subbasin Summary of Hydrologic Processes Environmental Consequences (bolded text represents most substantial changes from NAA)**

| Location | No Action Alternative | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| Fern Ridge Reservoir[1] | Would reach top of conservation storage about 50% of years during the spring. Fall drawdown to prepare for flood operations. | Would reach top of conservation storage about 50% of years during the spring. Fall drawdown to prepare for flood operations. | Would reach top of conservation storage about 50% of years during the spring. Fall drawdown to prepare for flood operations. | Would reach top of conservation storage about 50% of years during the spring. Fall drawdown to prepare for flood operations. | Would reach top of conservation storage about 50% of years during the spring. Fall drawdown to prepare for flood operations. | Would reach top of conservation storage about 50% of years during the spring. Fall drawdown to prepare for flood operations. | Would reach top of conservation storage about 50% of years during the spring. Fall drawdown to prepare for flood operations. | Would reach top of conservation storage about 50% of years during the spring. Fall drawdown to prepare for flood operations. |
| Long Tom at Monroe | Would maintain 50 cfs summer target. Winter regulation maximum | Would maintain 50 cfs summer target. Winter regulation would match NAA. | Would maintain 50 cfs summer target. Winter regulation would match NAA. | Would maintain 50 cfs summer target. Winter regulation would match NAA. | Would maintain 50 cfs summer target. Winter regulation would match NAA. | Would maintain 50 cfs summer target. Winter regulation would match NAA. | Would maintain 50 cfs summer target. Winter regulation would match NAA. | Would maintain 50 cfs summer target. Winter regulation would match NAA. |

| Location | No Action Alternative | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| | target of 6,000 cfs. | | | | | | | |

[1.] Fern Ridge top and bottom of conservation storage are elevation 373.5 and 353 ft, respectively.

## Table 3.2-4. McKenzie Subbasin Summary of Hydrologic Processes Environmental Consequences (bolded text represents most substantial changes from NAA)

| Location | No Action Alternative | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| Blue River Reservoir1 | Would reach top of conservation storage more than 50% of years during the spring and the bottom of conservation storage about 5% of years in late fall. | Would reach top of conservation storage **about 95%** of years during the spring and **Would very rarely reach** the bottom of conservation storage fall. Winter operations similar to the NAA. | Would reach top of conservation storage **about 75%** of years during the spring and the bottom of conservation storage about 5% of years in late fall. Winter operations similar to the NAA. | Would reach top of conservation storage **about 75%** of years during the spring and the bottom of conservation storage about 5% of years in late fall. Winter operations similar to the NAA. | Would reach top of conservation storage **about 75%** of years during the spring and would reach **lower minimum elevation** 5% of years. Increased winter storage space from deeper fall reservoir drawdown. | Would reach top of conservation storage **about 75%** of years during the spring and would **very rarely reach bottom of conservation** prior to fall drawdown. Increased winter storage space from deeper fall reservoir drawdown. | Would reach top of conservation storage **about 75%** of years during the spring and the bottom of conservation storage about 5% of years in late fall. Winter operations similar to the NAA. | Would reach top of conservation storage **about 75%** of years during the spring and the bottom of conservation storage about 5% of years in late fall. Winter operations similar to the NAA. |
| Blue River Outflow | Would meet downstream flow targets in nearly all years. | **Steadier flow** and slightly lower flow in spring of dry years as reservoir fills. | **Slightly lower flow** in spring of dry years as reservoir fills. Would meet downstream | **Slightly lower flow** in spring of dry years as reservoir fills. Would meet downstream | **Higher flow in summer** due to mainstem Willamette flow targets and would | **Higher flow in summer** due to mainstem Willamette flow targets. Would meet | Slightly **lower flow in spring** of dry years as reservoir fills. Would meet downstream | Slightly **lower flow in spring** of dry years as reservoir fills. Would meet downstream |

| Location | No Action Alternative | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| | | Would meet downstream flow targets in nearly all years. | flow targets in nearly all years. | flow targets in nearly all years. | **miss downstream flow targets** in fall of the driest years. | downstream flow targets in nearly all years. | flow targets in nearly all years. | flow targets in nearly all years. |
| Cougar Reservoir[2] | Would reach top of conservation storage about 50% of years during the spring and the bottom of conservation storage about 5% of years in late fall. | Would reach top of conservation storage **more than 75%** of years during the spring and lower minimum elevation about 5% of years in late fall. | Would reach top of conservation storage **less than 75%** of years during the spring and lower minimum elevation about 5% of years in late fall. | Would **never reach** the top of conservation storage and reaches very low minimum elevation about 25% of years. **Increased winter storage space** from deeper fall reservoir drawdown. | Would **never reach** the top of conservation storage and reaches lower minimum elevation about 60% of years. **Increased winter storage space** from deeper fall reservoir drawdown. | Would **never reach** the top of conservation storage and reaches very low minimum elevation about 25% of years. **Increased winter storage space** from deeper fall reservoir drawdown. | Reaches top of conservation storage **less than 75%** of years during the spring and lower minimum elevation about 5% of years in late fall. | **Never** reaches the top of conservation storage and reaches **very low minimum elevation about 25% of years. Increased winter storage space** from deeper fall reservoir drawdown. |
| Cougar Outflow | Would meet downstream flow targets in nearly all years. | **Steadier flow** and slightly lower flow in spring of dry years as reservoir fills. Would meet downstream flow targets in nearly all years. | **Slightly lower flow** in spring of dry years as reservoir fills. **Higher summer flow in dry years.** | **Higher spring flow** for spring reservoir drawdown. Would meet downstream targets in **about 75% wettest years,** with lower flows throughout summer. | **Higher spring flow** for spring reservoir drawdown. Would meet downstream targets in **about 40% wettest years,** with lower flows throughout summer. | **Higher spring flow** for spring reservoir drawdown. Would meet downstream targets in **about 75% wettest years,** with lower flows throughout summer. | **Slightly lower flow** in spring of dry years as reservoir fills. Higher summer flow in dry years. | **Higher spring flow** for spring reservoir drawdown. Would meet downstream targets **in about 75%** wettest years, with lower flows throughout summer. |

| Location | No Action Alternative | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| McKenzie at Vida | Elevated spring flow due to mainstem Willamette flow targets. Summer/fall flow about 1,500 cfs in very dry years. | **Lower spring** and **higher summer flows.** Summer/fall flow about **1,400 cfs** in very dry years. | **Lower spring** and similar summer flows. Summer/fall flow about **1,700 cfs** in very dry years. | **Lower spring** flow in dry years and **lower summer/fall** flow in wet years. Summer/fall flow about 1,500 cfs in very dry years. | **Lower spring** flow in dry years and **lower summer/fall flow** across all years. Summer/fall flow about **1,400 cfs** in very dry years. | **Lower spring** flow in dry years and **lower summer/fall** flow in wet years. Summer/fall flow about 1,500 cfs in very dry years. | **Lower spring** and similar summer flows. Summer/fall flow about **1,700 cfs** in very dry years. | **Lower spring flow** in dry years and **lower summer/fall flow in wet years**. Summer/fall flow about **1,400 cfs** in very dry years. |

1. Blue River top and bottom of conservation storage are elevation 1350 and 1180 ft, respectively.

2. Cougar top and bottom of conservation storage are elevation 1690 and 1532 ft, respectively.

## Table 3.2-5. Middle Fork of the Willamette Subbasin Summary of Hydrologic Processes Environmental Consequences (bolded text represents most substantial changes from NAA)

| Location | No Action Alternative | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| Hills Creek Reservoir[1] | Would reach top of conservation storage less than 50% of years during the spring and the bottom of conservation storage about 5% of years in late fall. | Would reach top of conservation storage **more than 75%** of years during the spring and **lower minimum elevation** about 5% of years in late fall. | Would reach top of conservation storage **less than 75%** of years during the spring and **lower minimum elevation about 10%** of years in late fall. | Would reach top of conservation storage **less than 75%** of years during the spring and **lower minimum elevation about 10%** of years in late fall. | Would reach top of conservation storage **less than 75%** of years during the spring and the bottom of conservation **about 75%** of years in summer/fall, with an **average of middle of September.** | **Would never** reach the top of conservation storage and the would reach bottom of conservation **50% of years.** | Would reach top of conservation storage **less than 75%** of years during the spring and **lower minimum elevation about 10%** of years in late fall. | Would reach top of conservation storage **about** 50% of years during the spring and **lower minimum elevation about 20%** of years in late fall. |

| Location | No Action Alternative | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| Hills Creek Outflow | Flow would meet downstream flow targets in nearly all years. Minimum flow about 350 cfs. | Flow **higher in spring and summer** of average and wetter years. **Flow would miss** downstream flow target in fall of **driest years**. Minimum flow about **250 cfs.** | **Higher flow in spring and summer** of average and wetter years. **Flow would miss** downstream flow target in fall of **driest years**. Minimum flow about **250 cfs.** | **Higher flow in spring and summer** of average and wetter years. **Flow would miss** downstream flow target in fall of **driest years**. Minimum flow about **250 cfs.** | **Higher flow in spring/early summer.** Flow downstream would be below target for at least **two months in dry years.** Minimum flow about **250 cfs.** | **Higher spring flow**. Flow downstream would be below target for at least **three months in dry years.** At target in all other years. Minimum flow about **220 cfs.** | **Higher flow in spring and summer** of average and wetter years. **Flow would miss** downstream flow target in fall of **driest years**. Minimum flow about **250 cfs.** | **Higher flow in spring and summer** of average and wetter years. **Flow would miss** downstream flow target in summer and fall of **driest years**. Minimum flow about **230 cfs.** |
| Lookout Point Reservoir[2] | Would reach top of conservation storage about 75% of years during the spring and the bottom of conservation storage about 5% of years in late fall. | Would reach top of conservation storage about 75% of years during the spring and **lower minimum elevation** about 5% of years in late fall. | Would reach top of conservation storage about 75% of years during the spring and **lower minimum elevation** about 5% of years in late fall. | Would reach top of conservation storage about 75% of years during the spring and **lower minimum elevation about 10%** of years in late fall. | Would **never** reaches the top of conservation storage and **lower minimum elevation** 5% of years. **Increased winter storage space** from deeper fall reservoir drawdown. | Would reach top of conservation storage **more than 75%** of years during the spring and **lower minimum elevation** about 5% of years in **summer. Increased winter storage space** from deeper fall reservoir drawdown. | Would reach top of conservation storage about 75% of years during the spring and **lower minimum elevation** about 5% of years in late fall. | Would reach top of conservation storage about 75% of years during the spring and **lower minimum elevation about 10%** of years in late fall. |
| Lookout Point/ | Would miss downstream | **Lower flow in spring** and | Minor differences to | Would miss downstream | **Higher flow in spring** and | **Higher spring flow.** Would | Minor differences to | Would miss downstream |

| Location | No Action Alternative | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| Dexter Outflow | flow target in October of driest years. | **higher flow in summer/fall**. Would miss downstream flow target in October of driest years. | NAA. Would miss downstream flow target in October of driest years. | flow target in **September and October** of driest years. | **minimum flow in summer across all years.** Would miss downstream flow target in **fall** of driest years. | miss downstream flow target from **August to October.** | NAA. Would miss downstream flow target in October of driest years. | flow target in **late August through October** of driest years. |
| Fall Creek Reservoir[3] | Would reach top of conservation storage less than 75% of years during the spring and would very rarely reach the bottom of conservation storage prior to fall drawdown. | Would reach top of conservation storage **about 75%** of years during the spring and would very rarely reach the bottom of conservation storage prior to fall drawdown. | Would reach top of conservation storage **about 75%** of years during the spring and would very rarely reach the bottom of conservation storage prior to fall drawdown. | Would reach top of conservation storage **about 75%** of years during the spring and would very rarely reach the bottom of conservation storage prior to fall drawdown. | Would reach top of conservation storage **about 75%** of years during the spring and would very rarely reach the bottom of conservation storage prior to fall drawdown. | Would reach top of conservation storage **about 75%** of years during the spring and would very rarely reach the bottom of conservation storage prior to fall drawdown. | Would reach top of conservation storage **about 75%** of years during the spring and would very rarely reach the bottom of conservation storage prior to fall drawdown. | Would reach top of conservation storage **about 75%** of years during the spring and would very rarely reach the bottom of conservation storage prior to fall drawdown. |
| Fall Creek Outflow | Flow would meet downstream flow targets. | **Lower spring flow**. Flow would meet downstream flow targets. | **Lower spring flow**. Flow would meet downstream flow targets. | **Lower spring flow**. Flow would meet downstream flow targets. | **Lower spring flow**. Flow would meet downstream flow targets. | **Lower spring flow**. Flow would meet downstream flow targets. | **Lower spring flow**. Flow would meet downstream flow targets. | **Lower spring flow**. Flow would meet downstream flow targets. |
| Middle Fork of the Willamette at Jasper | Elevated spring flow due to mainstem Willamette flow targets. Fall flow about | **Lower spring flow** in dry years and **higher summer/fall flow** across all years. Flow | **Lower spring flow** and **higher summer/fall flow** in dry years. Average and wetter | **Lower spring flow** and **September of driest years**. Higher flow in fall of most years. Flow | **Higher spring flows.** Summer/fall flow at **minimum for three months** for all years. | **Lower spring flow** in dry years. Flow at **1,100 cfs for two months** in very dry years. | **Lower spring flow** and **higher summer/fall flow** in dry years. Average and wetter | **Lower spring flow, late August and September of driest years**. Higher flow in fall of most |

| Location | No Action Alternative | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| | 1,200 cfs in very dry years. | about **1,100 cfs** in very dry years. | years similar. Flow about **1,500 cfs** in very dry years. | about **1,300 cfs** in very dry years. | Flow about **1,100 cfs for five months** in very dry years. | | years similar. Flow about **1,500 cfs** in very dry years. | years. Flow about **1,100 cfs** in very dry years. |

1. Hills Creek top and bottom of conservation storage are elevation 1541 and 1448 ft, respectively.

2. Lookout Point top and bottom of conservation storage are elevation 926 and 825, respectively.

3. Fall Creek top and bottom of conservation storage are elevation 830 and 728 ft, respectively.

**Table 3.2-6. Coast Fork of the Willamette Subbasin Summary of Hydrologic Processes Environmental Consequences (bolded text represents most substantial changes from NAA)**

| Location | No Action Alternative | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| Dorena Reservoir[1] | Would reach top of conservation storage about 50% of years during the spring and the bottom of conservation storage about 5% of years in late fall. | Would reach top of conservation storage **less than 75%** of years during the spring and would **very rarely reach lower minimum elevation.** | Would reach top of conservation storage **more than 50%** of years and would **very rarely reach** the bottom of conservation storage. | Would reach top of conservation storage **more than 50%** of years and would **very rarely reach** the bottom of conservation storage. | Would reach top of conservation storage **more than 50%** of years during the spring and **lower minimum elevation** about 5% of years in late fall. | Would reach top of conservation storage **more than 50%** of years during the spring and **lower minimum elevation about 25%** of years in late fall. | Would reach top of conservation storage **more than 50%** of years during the spring and **lower minimum elevation about 25%** of years in late fall. | Would reach top of conservation storage about 50% of years during the spring and the bottom of conservation storage about 5% of years in late fall. |
| Dorena Outflow | Would maintain minimum flows except in November of driest years. | Would maintain minimum flows in **nearly all years.** | Would maintain minimum flows except in November of driest years. | Would maintain minimum flows except in November of driest years. | Would maintain minimum flows except in November of driest years. | Would maintain minimum flows except in November of **dry years.** | Would maintain minimum flows in **nearly all years.** | Would maintain minimum flows except in November of driest years. |
| Cottage Grove Reservoir[2] | Would reach top of conservation | Would reach top of conservation | Would reach top of conservation | Would reach top of conservation | Would reach top of conservation | Would reach top of conservation | Would reach top of conservation | Would reach top of conservation |

| Location | No Action Alternative | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| | storage less than 50% of years during the spring and the bottom of conservation storage about 5% of years in late fall. | storage **more** than 50% of years during the spring and would **very rarely reach lower minimum elevation.** | storage **about** 50% of years during the spring and would **very rarely reach** the bottom of conservation storage. | storage **about** 50% of years during the spring and would **very rarely reach** the bottom of conservation storage. | storage **more** than 50% of years during the spring and **lower minimum elevation** in more than **5% of years in November.** | storage **about** 50% of years during the spring and **lower minimum elevation in about 25% of years in November.** | storage **about** 50% of years during the spring and **lower minimum elevation in about 25% of years in November.** | storage less than 50% of years during the spring and the bottom of conservation storage about 5% of years in late fall. |
| Cottage Grove Outflow | Would maintain minimum flows except in November of driest years. | Would maintain minimum flows **in nearly all years.** | Would maintain minimum flows except in November of driest years. | Would maintain minimum flows except in November of driest years. | Would maintain minimum flows except in November of driest years. | Would maintain minimum flows except in November of driest years. | Would maintain minimum flows except in November of driest years. | Would maintain minimum flows except in November of driest years. |
| Coast Fork of the Willamette at Goshen | Elevated spring flow due to mainstem Willamette flow targets. Low flow in November about 80 cfs in very dry years. | **Lower spring** and **higher summer** flow in dry years. Low flow in **October about 150 cfs** in very dry years. | **Lower spring** flow in dry years. Low flow in November about 80 cfs in very dry years. | **Lower spring** flow in dry years. Low flow in November about 80 cfs in very dry years. | **Lower spring** and **higher summer** flow in dry years. Low flow in November about **90** cfs in very dry years. | **Lower spring** flow in dry years. Low flow in November about **90** cfs in very dry years. | **Lower spring** flow in dry years. Low flow in November about **100** cfs in very dry years. | **Lower spring** flow in dry years. Low flow in November about 80 cfs in very dry years. |

1. Dorena top and bottom of conservation storage are elevation 832 and 771 ft, respectively.

2. Cottage Grove top and bottom of conservation storage are elevation 790 and 750 ft, respectively.

**Table 3.2-7. Mainstem Willamette River Summary of Hydrologic Processes Environmental Consequences (bolded text represents most substantial changes from NAA)**

| Location | No Action Alternative | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| Willamette River at Harrisburg | Elevated spring flow due to downstream flow targets. Low flow in October about 3,000 cfs of very dry years. | **Lower spring flow** in dry years and **higher summer flow.** Low flow in October about 3,000 cfs of very dry years. | **Lower spring flow** in dry years. Less variation in summer flow. Low flow in October about **3,700 cfs** of very dry years. | **Lower spring flow** in dry years. Less variation in summer flow. Low flow in October about **3,300 cfs** of very dry years. | Increased **spring flow variation. Lower summer flow** across all years. Low flow in **August about 2,800 cfs** of very dry years. | **Lower spring flow** in dry years. Less variation in summer flow. Low flow in **September about 2,900 cfs** of very dry years. | **Lower spring flow** in dry years. Less variation in summer flow. Low flow in October about **3,700 cfs** of very dry years. | **Lower spring flow** in dry years. Less variation in summer flow. Low flow in October about **2,900** cfs of very dry years. |
| Willamette River at Albany | Elevated spring flow in dry years due to downstream flow target. Would miss baseline flow target from July to October in driest years. Low flow in August about 3,200 cfs of very dry years. | **Lower spring flow** in dry years. Would miss flow target in **October** of driest years. Low flow in **October about 3,000 cfs** of very dry years. | **Lower spring flow** in dry years. Somewhat lower summer flow, while meeting flow target in nearly all years. Low flow in **October about 4,000** cfs of very dry years. | **Lower spring flow** in dry years. Somewhat lower summer flow and would **miss flow target in September and October** of driest years. Low flow **about 4,000** cfs of very dry years. | Increased **spring flow variation. Much lower summer flow.** Misses flow target in about **80% of years. Typical year would miss target** for about two months. Low flow in **September about 3,000 cfs** of very dry years. | Increased **spring flow variation.** Would miss baseline flow target from August to October in driest years. Low flow in **October** about 3,200 cfs of very dry years. | **Lower spring flow** in dry years. Somewhat lower summer flow and would meet flow target in nearly all years. Low flow in **October about 3,800** cfs of very dry years. | **Lower spring flow** in dry years. Somewhat lower summer flow and would **miss flow target in late August through October** of driest years. Low flow in **September** about **3,300** cfs of very dry years. |
| Willamette River at Salem | Spring flow below baseline target more than 25% of | **Lower spring flow** in dry years. **Higher summer flow** | **Lower spring flow** would meet lower seasonal | **Lower spring flow** would meet lower seasonal | **Lower spring flow** would meet lower seasonal | **Lower spring flow** would meet lower seasonal | **Lower spring flow** would meet lower seasonal | **Lower spring flow** would meet lower seasonal |

| Location | No Action Alternative | Alternative 1 | Alternative 2A | Alternative 2B | Alternative 3A | Alternative 3B | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|---|---|---|
| | years. Summer flow below baseline target in 5% of years for about four months. Low flow in August about 4,800 cfs of very dry years. | across all years. Flow would **miss lower target in October of driest years.** Low flow in **October about 5,500 cfs** of very dry years. | target. **Higher summer flow and elevated fall flow** from Green Peter deeper fall reservoir drawdown. Low flow in August about **6,200 cfs** of very dry years. | target. **Higher summer flow and elevated fall flow** from Green Peter deeper fall reservoir drawdown. Low flow in August about **6,200 cfs** of very dry years. | target. Lower summer flow **misses lower target in August** of driest years. Low flow in August about **4,000 cfs** of very dry years. | target. Lower summer flow **misses lower target very rarely in August.** Low flow in August about **4,500 cfs** of very dry years. | target. Higher summer and fall flow in dry years. Low flow in August about **6,100 cfs** of very dry years. | target. **Higher summer flow and elevated fall flow** from Green Peter deeper fall reservoir drawdown. Low flow in August about **5,900 cfs** of very dry years. |

### *3.2.2.3 No Action Alternative*

The NAA would represent the current management direction. For this analysis, the No Action Alternative may be thought of in terms of continuing with the present course of actions with respect to how USACE manages the WVS until that action is changed. With respect to the NAA, the following assumptions can be made:

- Rule curves across the WVS would remain as they currently operate. Relatively recent changes such as the Fall Creek fall draw down are simulated across the complete period of record.
- Currently in-progress projects are included, even if they are not fully implemented at time of analysis. Regulation operations intended to be temporary, even if currently active, are not included.
- USACE would continue to operate the WVS to meet mainstem and tributary flow objectives to the maximum extent possible as described in the 2008 NMFS BiOp (NMFS 2008) and implemented per the Willamette Fish Operations Plan (USACE 2017a).
- Additional releases and downstream withdrawals to satisfy anticipated municipal and industrial (M&I) water storage agreements.
- Only those measures that affect the amount of flow through a dam and reservoir or change the flow of an outlet are modeled in reservoir regulation model (HEC-ResSim). Actions that change other variables, such as a WTC tower, are not included in the HEC-ResSim and these changes will not be reflected in the charts in this section.

The primary purpose of the NAA is to compare the existing WVS management with each of the alternatives. Comparisons with the baseline will show meaningful differences in flow and reservoir water surface elevations across the basin rather than only looking at each alternative in isolation.

As explained in the Methodology section, the NAA does not attempt to reproduce observed past operations. In this way, the set of changes in each alternative can be compared to the NAA without the influence of other factors, such as reservoir regulator preferences. Also, all charts below show the calculated value for that date and do not reflect a specific year or sequence of flows or reservoir elevations. As an example, the average, or P50, line is the mean flow on that date across all years of the simulation; even a ‘typical’ year is very unlikely to exactly follow that sequence.

The NAA is designed to continue the current management practices of the WVS, with the addition of increased releases for M&I water storage agreements. Effects from the NAA to hydrologic processes: None/Negligible.

### *3.2.2.3.1 Santiam Subbasin*

Detroit reservoir (Figure 3.2-20) would reach the maximum conservation pool elevation more than 50 percent of years (blue P50) and would stay near the top of conservation pool for more than half the summer provided it does reach maximum pool. Even in the driest years (green P05), the pool would remain above the minimum conservation pool until September.

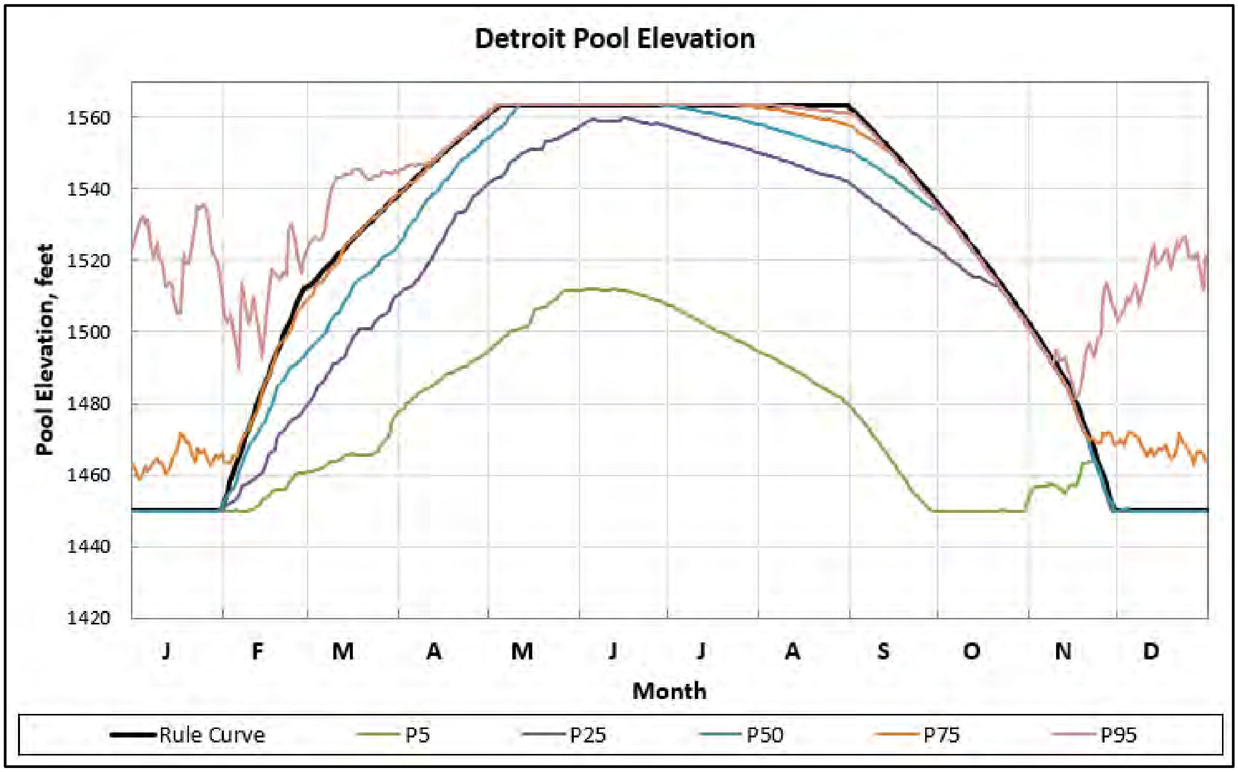



**Figure 3.2-20. NAA Detroit water surface elevation non-exceedance**

On the South Santiam, Green Peter (Figure 3.2-21) would also fill more than half the time (blue P50), but drafts below the rule curve earlier in the season. The Green Peter reservoir releases are an important component to meet 2008 NMFS BiOp (NMFS 2008) flow targets in the mainstem Willamette prior to drafting Detroit. Since all the stored water in both reservoirs is needed to meet downstream flow demands during the driest years, the green P05 line would reach minimum conservation pool at about the same time.

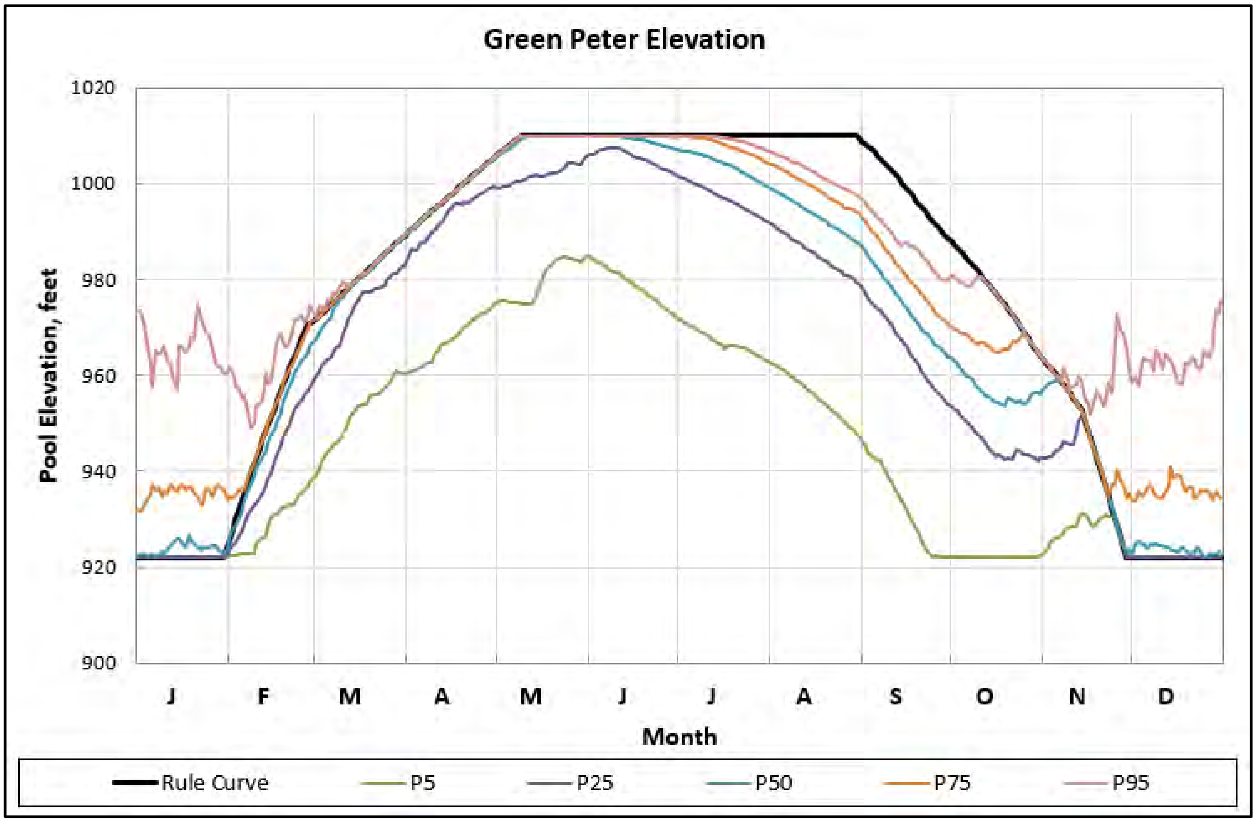



**Figure 3.2-21. NAA Green Peter water surface elevation non-exceedance**

Big Cliff and Foster are not shown as they primarily reregulate Detroit and Green Peter during conservation season, smoothing power peaking flow from the upstream dam, and therefore would follow the rule curve very closely in all years under the NAA.

Figure 3.2-22 shows the results of the regulation model for the Santiam River at Jefferson, a couple miles downstream of the confluence between the North and South Santiam Rivers. The figure combines the flow from the dams and the 'local' flows into the Santiam River from tributaries downstream of the WVS dams. The maximum flow reflects the high flows from high water events and floods. As the chart shows the maximum flow across the NAA, this shows that flows at or above bankfull (35,000 cfs) have occurred at Jefferson in every month except July, August, and September.

Mean and minimum flows would show much greater consistency throughout the year, reflecting 'typical' flows in the river and the minimum flows reached during an abnormally dry period. The dry periods do not reflect a single year but show that these dry periods that reduce flow can happen at any time during the year.

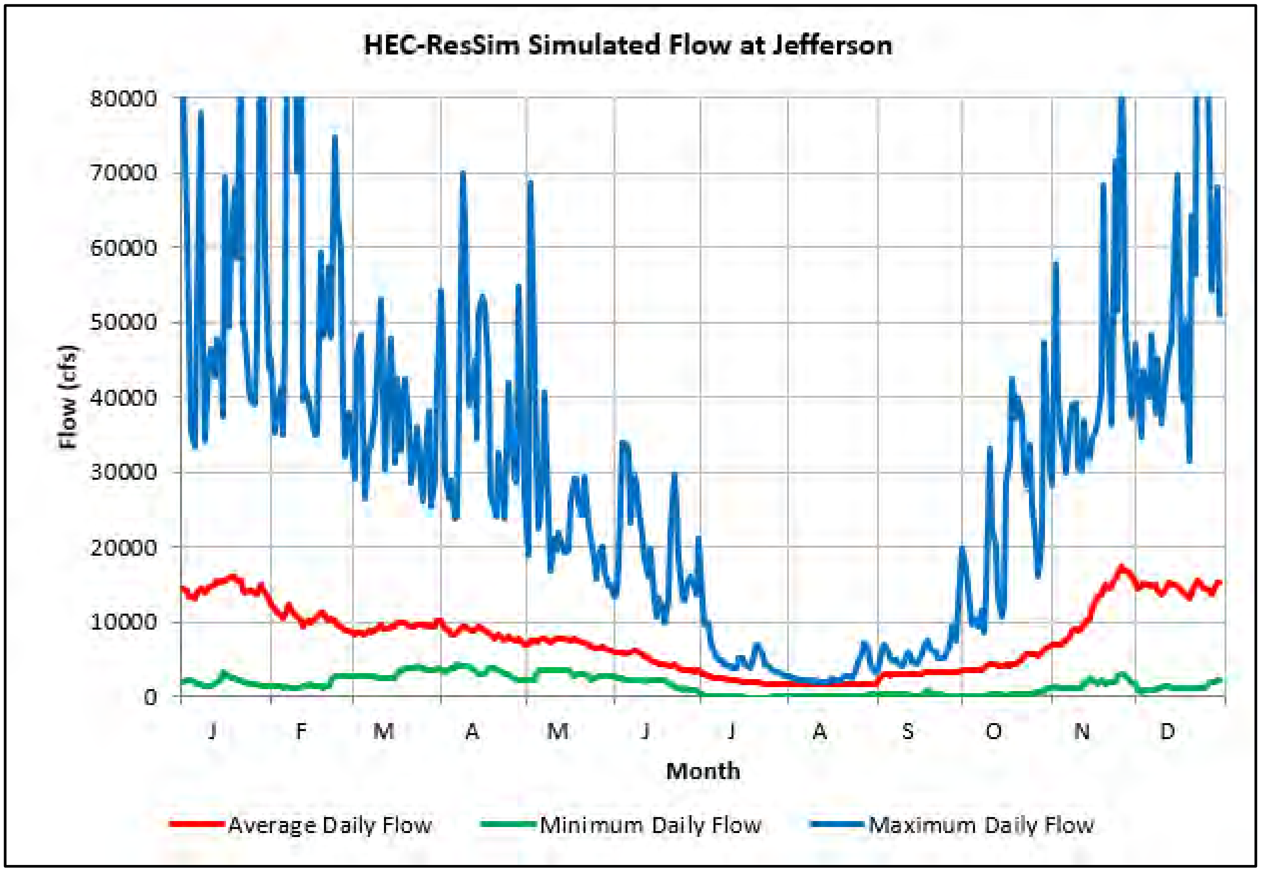



**Figure 3.2-22. NAA Santiam River at Jefferson daily minimum, average, and maximum flows**

#### *3.2.2.3.2 Long Tom Subbasin*

Fern Ridge reservoir (Figure 2.2-23) is relatively small in volume and shallow as compared to the other reservoirs in the WVS. Fern Ridge would reach within 6 feet of its maximum conservation pool in 95 percent of years (green P05 non-exceedance line) and USACE manages water levels to maintain the highest pool elevation possible until the rule curve falls starting in September. Fern Ridge has a small volume relative to other WVS reservoirs. Recreation and fish and wildlife habitat are a high priority at Fern Ridge, and other WVS reservoirs are drafted to meet downstream requirements prior to using the relatively limited water stored in Fern Ridge. Therefore, it is very rare for Fern Ridge to empty during the summer months.

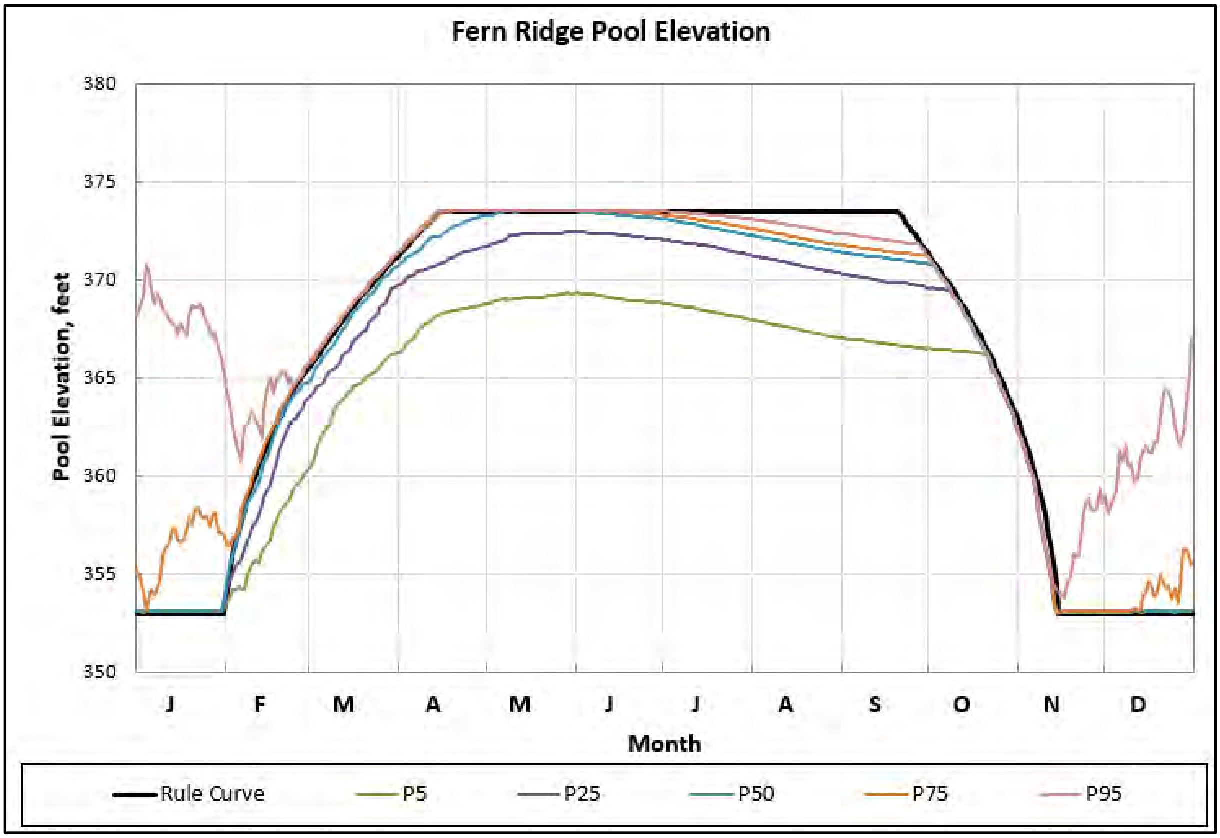



**Figure 3.2-23. NAA Fern Ridge water surface elevation non-exceedance**

Flow in the Long Tom River (Figure 3.2-24) downstream of Fern Ridge dam shows typical seasonal variation in the WRB. The high minimum flow in November is the flow out of the reservoir in preparation for winter flood season. Since USACE prioritizes keeping this reservoir relatively high through the fall in support of recreation and fish and wildlife habitat, there are no years in which the water has already left the pool (for a counterexample, see Green Peter in the Santiam Basin). Therefore, there is always an elevated November flow to return the reservoir to minimum pool.

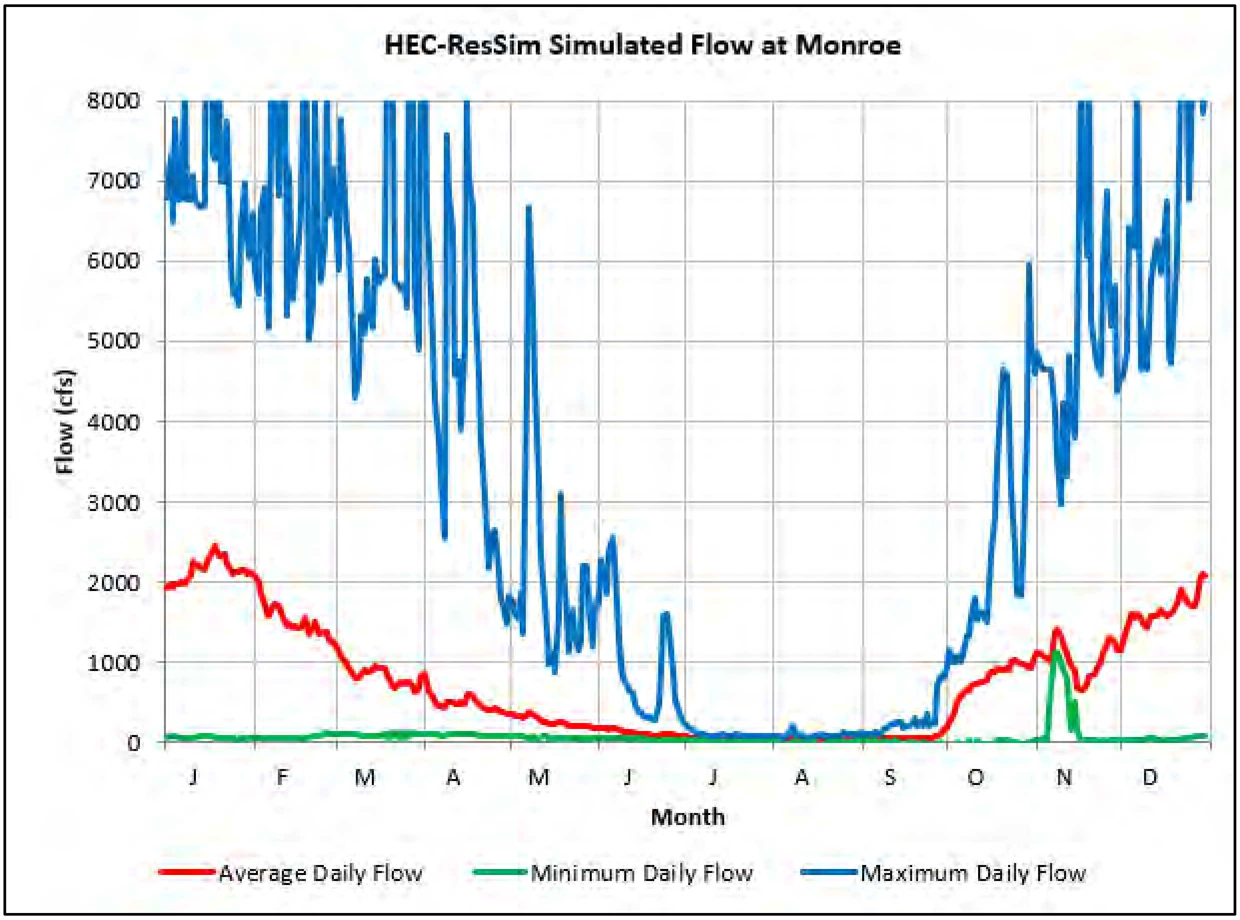



**Figure 3.2-24. NAA Long Tom River at Monroe daily minimum, average, and maximum flows**

*3.2.2.3.3 McKenzie Subbasin*

Cougar (Figure 3.2-25) and Blue River (Figure 3.2-26) would behave similarly with respect to their rule curves during average and wetter years. During drier years (the green P05 and purple P25), Cougar would draft toward its minimum conservation elevation more frequently than Blue River despite its larger capacity. This is because Cougar has hydropower turbines, dictating a higher minimum flow when running, and the reservoir's storage is more often used to meet minimum flows on the mainstem Willamette River at Albany and Salem.

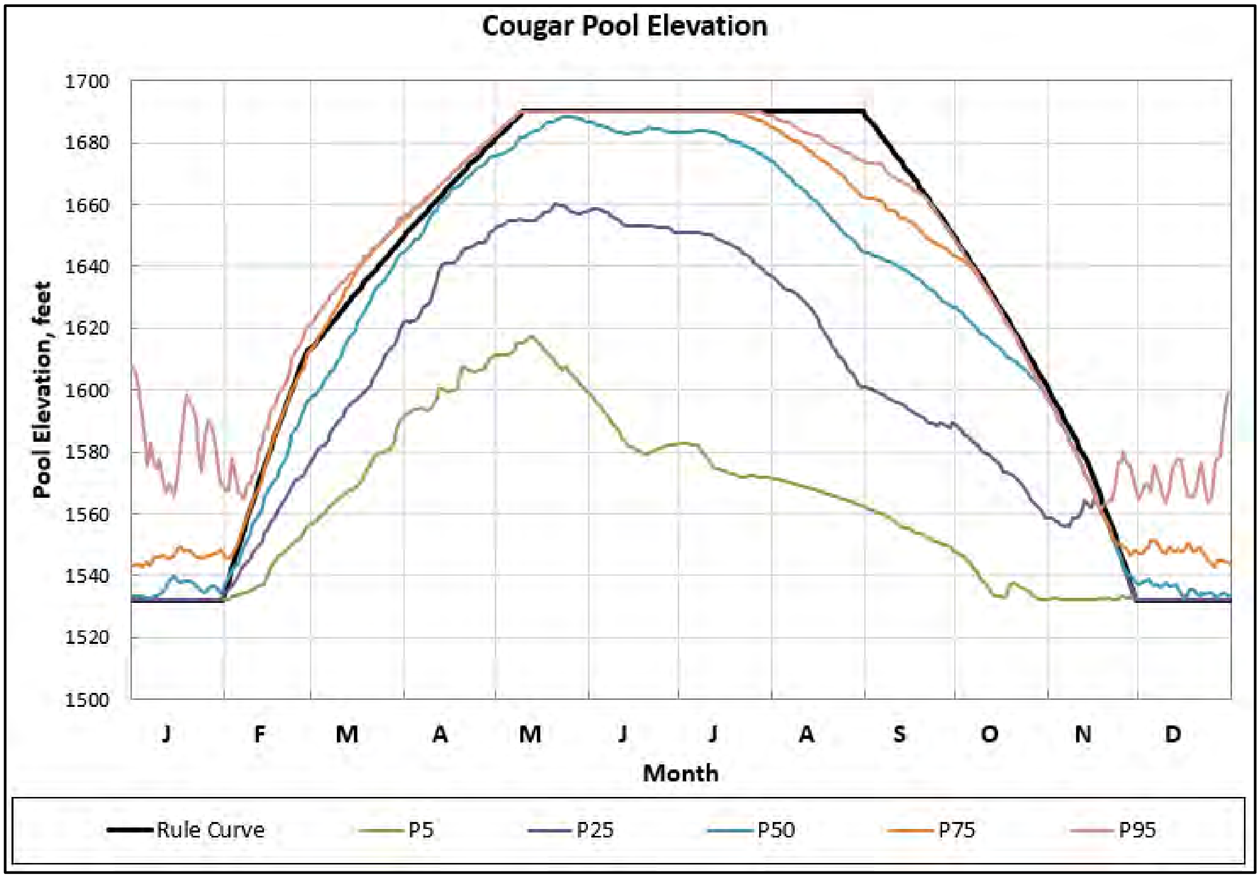



**Figure 3.2-25. NAA Cougar water surface elevation non-exceedance**

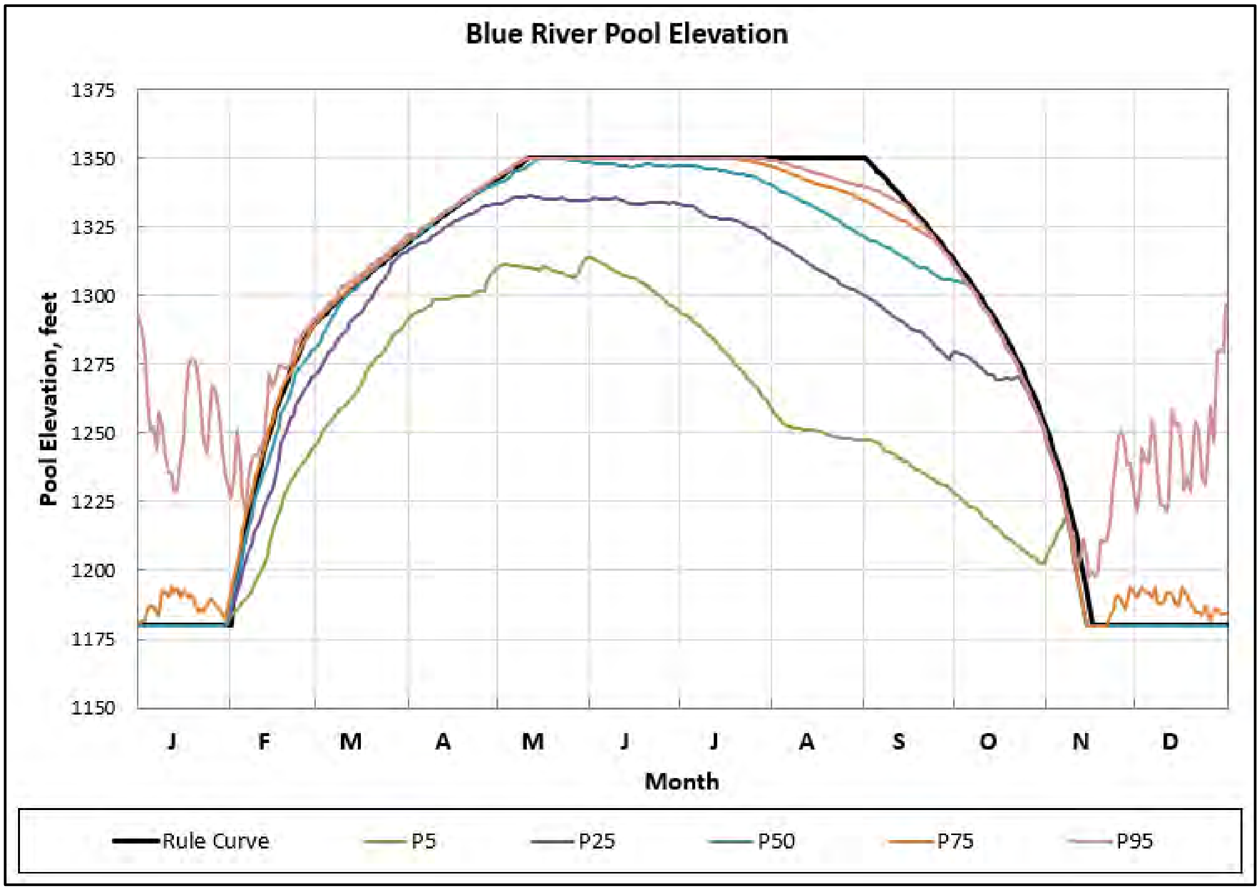



**Figure 3.2-26. NAA Blue River water surface elevation non-exceedance**

The minimum flow across the period of record at The McKenzie River at Vida (Figure 3.2-27) is higher relative to the average flow as compared to other Willamette Valley subbasins due to the geology in the upstream watershed. The control point for Blue River and Cougar is also downstream of the relatively large uncontrolled basin from the mainstem McKenzie River headwaters.

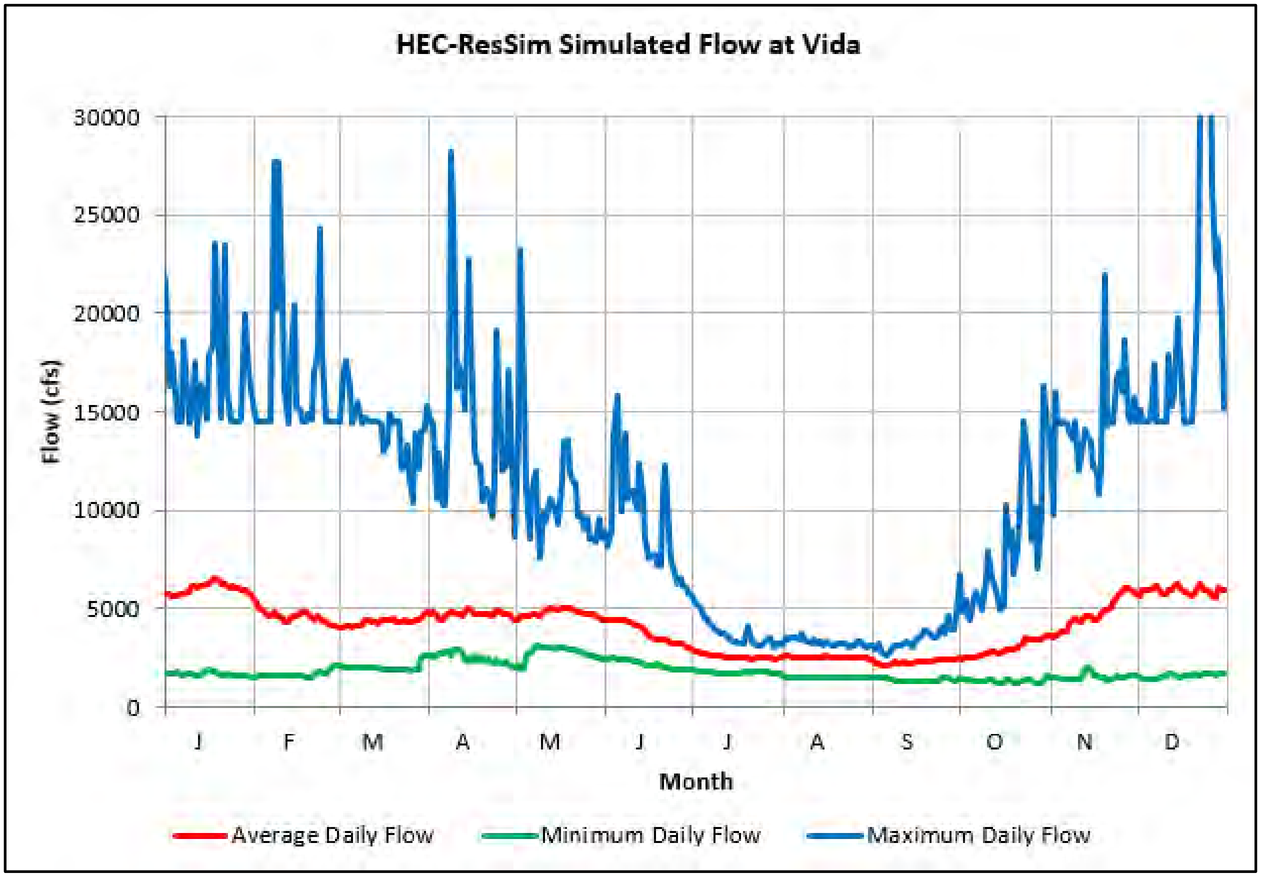



**Figure 3.2-27. NAA McKenzie River at Vida daily minimum, average, and maximum flows**

### *3.2.2.3.4 Middle Fork of the Willamette Subbasin*

Fall Creek reservoir (Figure 3.2-28) is fully drained each year by late November and early December to facilitate downstream passage of juvenile spring Chinook salmon. This deeper fall reservoir drawdown is implemented in the NAA. Although this is a relatively recent operation (the first one was in 2011), this operation is run throughout the period of record to reflect the current USACE management of the WVS. During the deeper fall reservoir drawdown period, there are still periods of higher water due to flood operations and Fall Creek has always been able to return to the minimum conservation pool elevation prior to the start of refill in February.

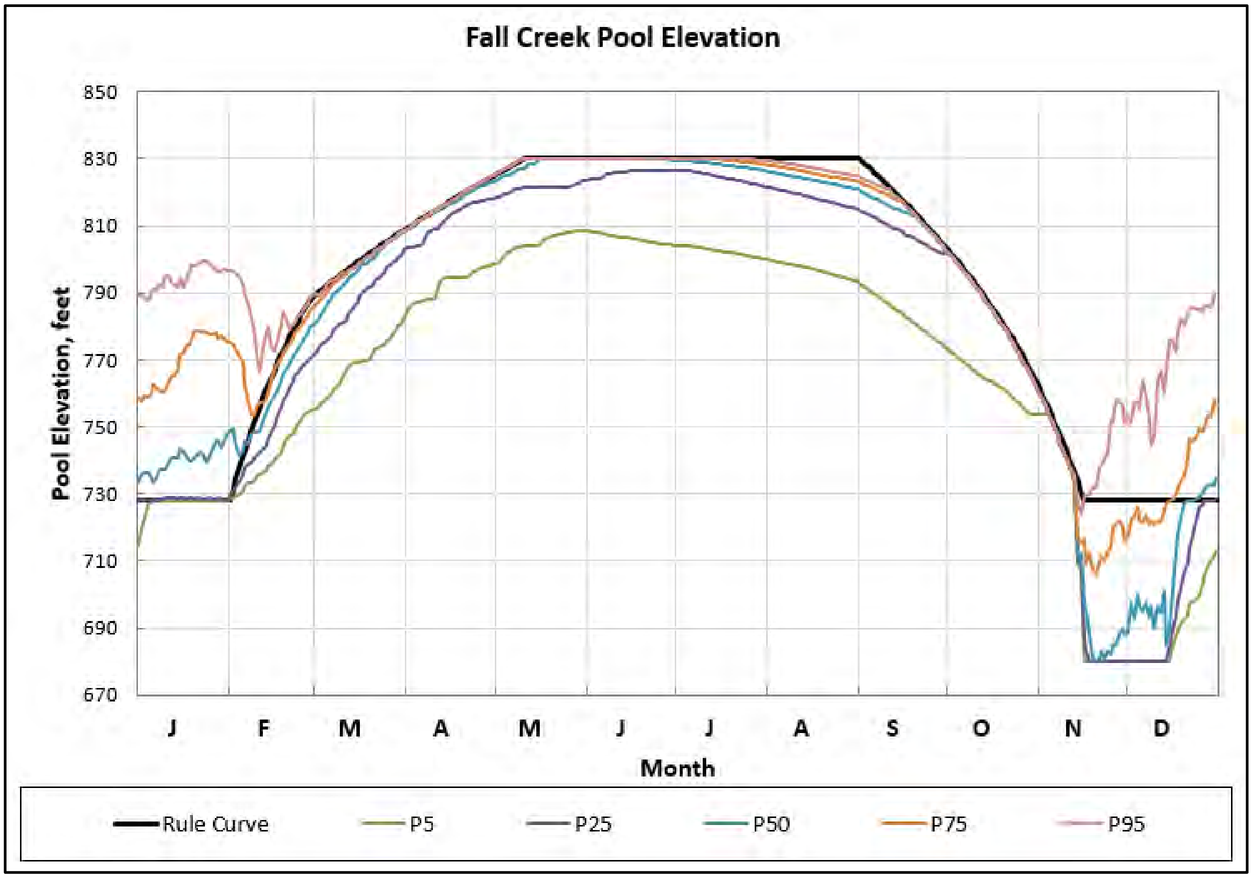



**Figure 3.2-28. NAA Fall Creek water surface elevation non-exceedance**

Hills Creek (Figure 3.2-29) is upstream of Lookout Point (Figure 3.2-30) and under the NAA, these projects would continue to be operated to balance water storage between them. Therefore, they would tend to follow a similar path in average to wet years. During drier years (purple P25 and green P05), flow leaving Hills Creek can be stored in Lookout Point so Lookout Point can remain higher for longer. The 'twice stored' water is required in the fall to meet downstream flow targets, so this effect only lasts through about early September. For example, the Lookout Point P25 line falls in September and October, whereas the Hills Creek line is already nearing its minimum annual level.

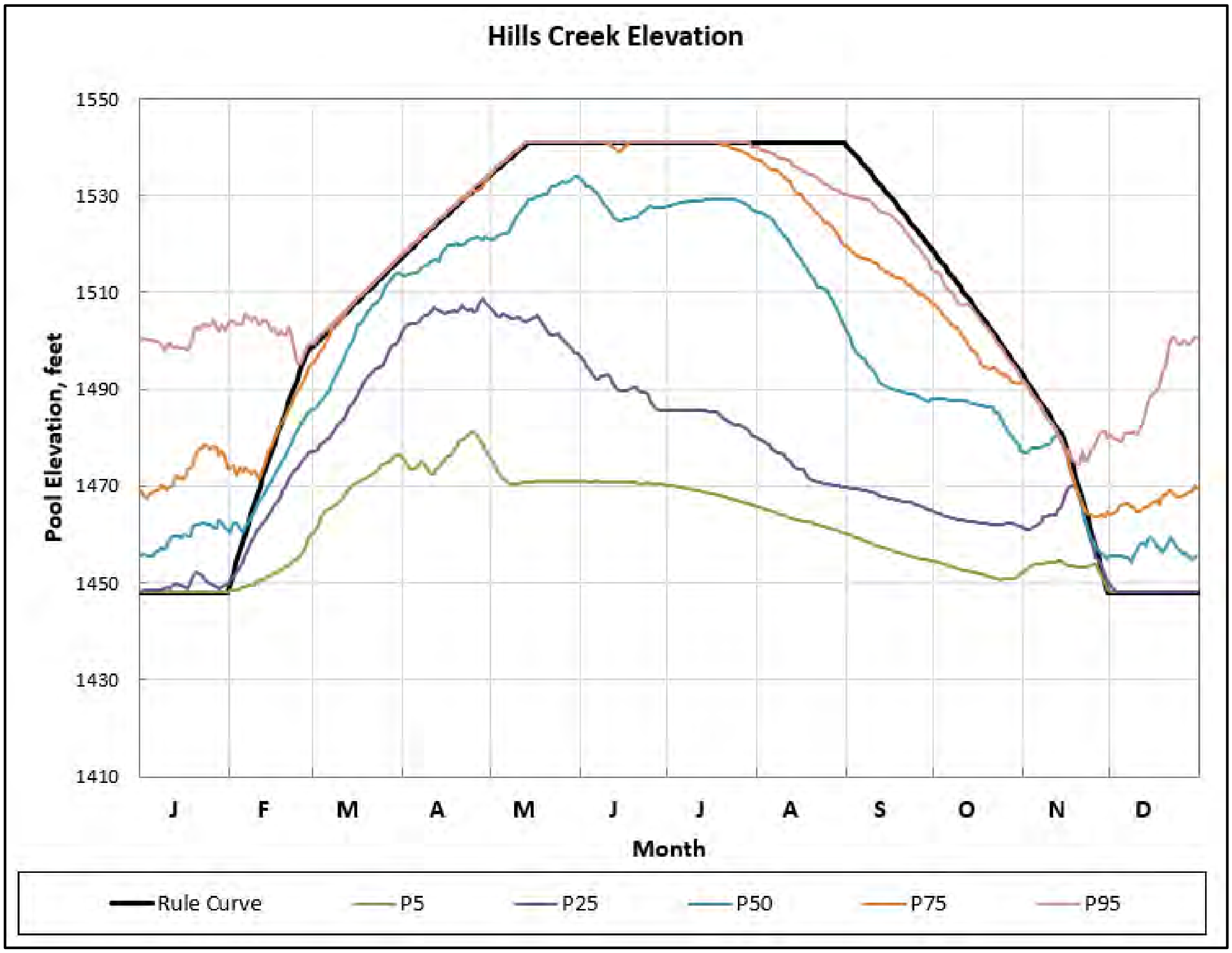



**Figure 3.2-29. NAA Hills Creek water surface elevation non-exceedance**

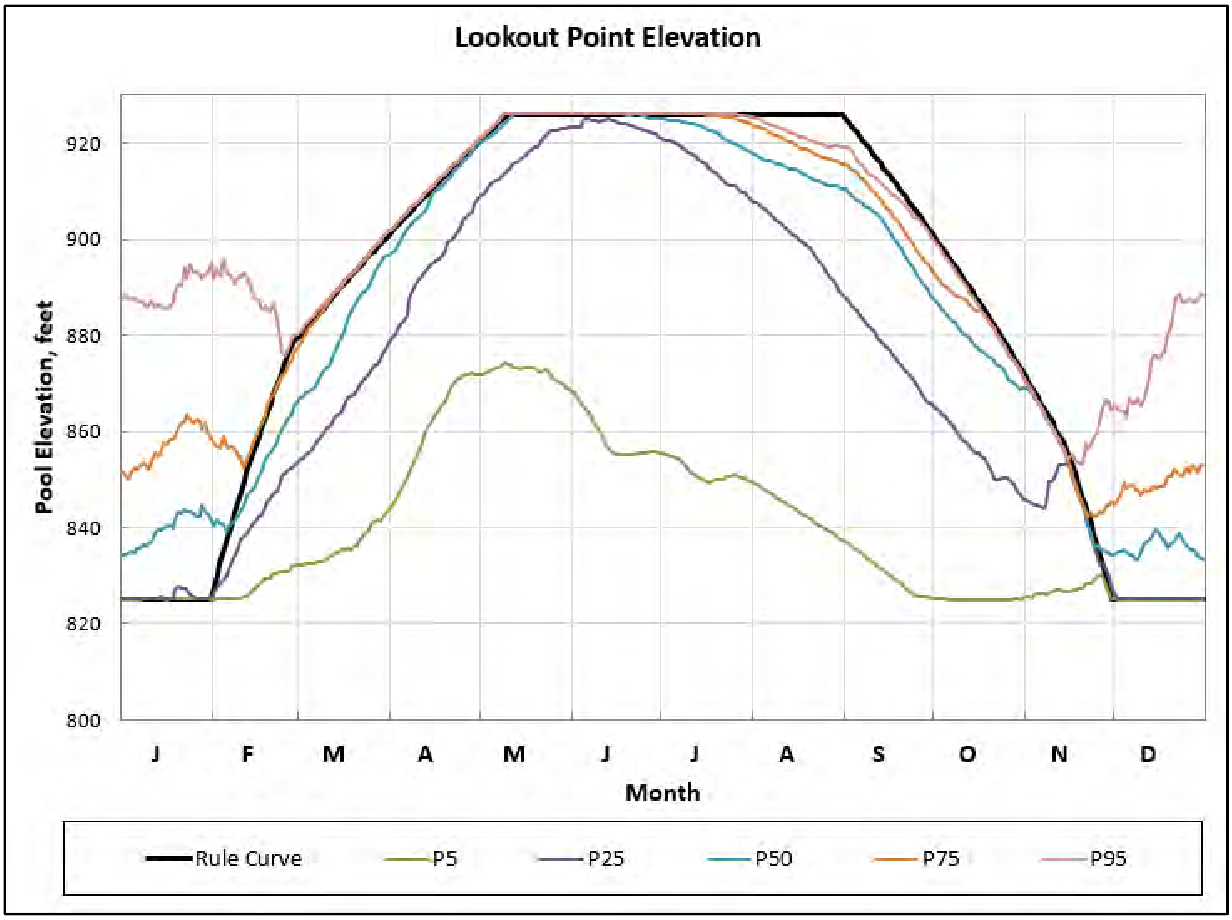



**Figure 3.2-30. NAA Lookout Point water surface elevation non-exceedance**

Dexter is not shown as it reregulates Lookout Point, smoothing power peaking flow. It follows its flat rule curve very closely in all years.

The downstream control point for Middle Fork of the Willamette at Jasper (Figure 3.2-31) shows a typical regulated shape for the Willamette. Flood season from November to April sees regular higher flows with a possibility of low flow at any time during the winter. The most consistently low flow is July through early September. The bankfull regulation target at Jasper is 20,000 cfs, so the maximum flows congregate around there during early winter as USACE drafts the reservoir in preparation for storing water during winter storm events. Since this is the maximum daily flow across all years, each individual year will reach bankfull for a much shorter time to draft the reservoir.

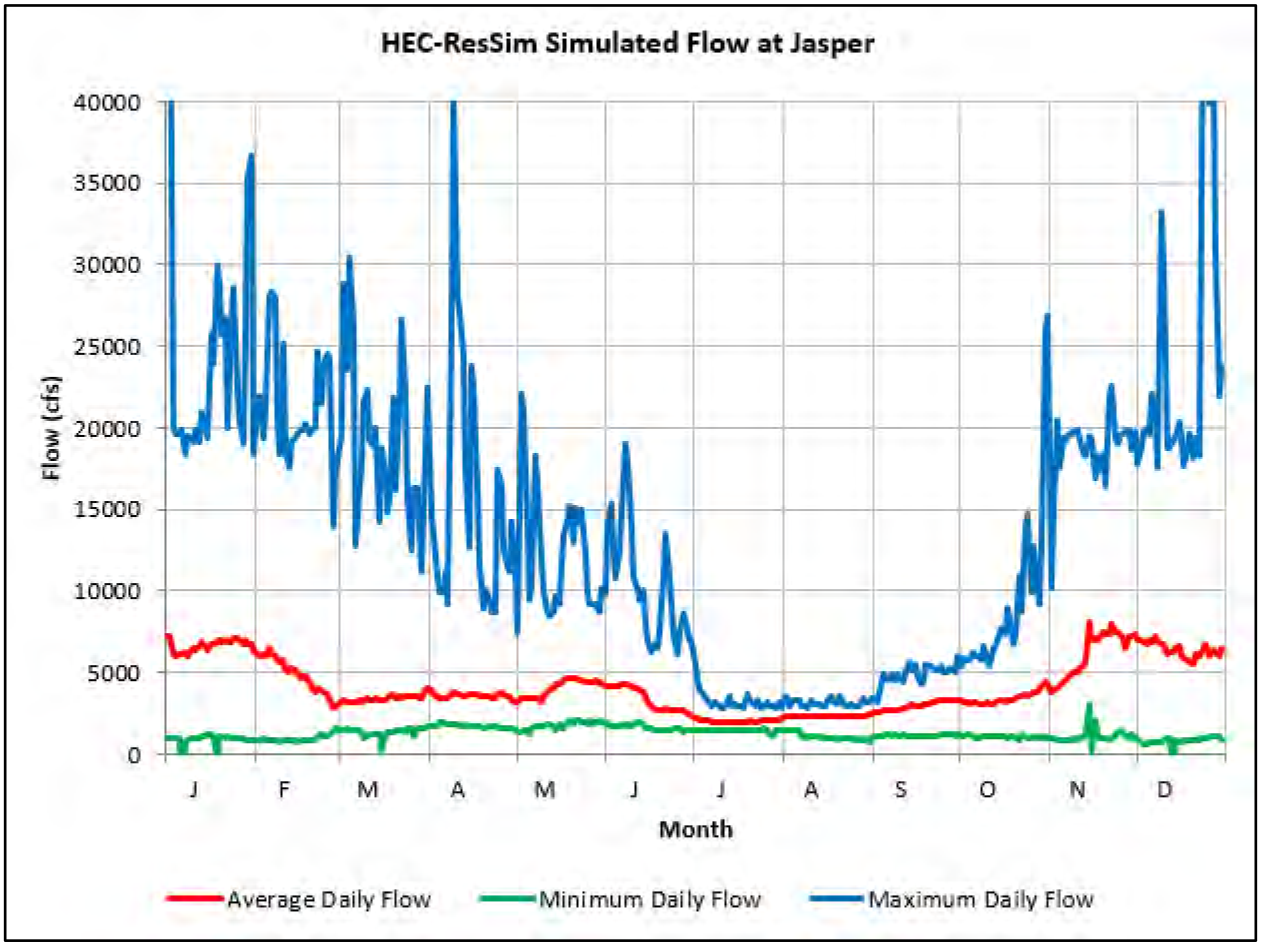



**Figure 3.2-31. NAA Middle Fork of the Willamette at Jasper daily minimum, average, and maximum flows**

*3.2.2.3.5 Coast Fork of the Willamette Subbasin*

Cottage Grove (Figure 3.2-32) and Dorena (Figure 3.2-33) operate very similarly in that they have the same control point and regulation goals. Although Dorena is a bit more than twice as large by volume, its drainage is also a little more than twice as large as Cottage Grove's drainage area. Dorena's drainage area is somewhat higher in average elevation, so the inflow to Dorena is more variable throughout the winter flood season. Summer storage season is very similar between the two reservoirs.

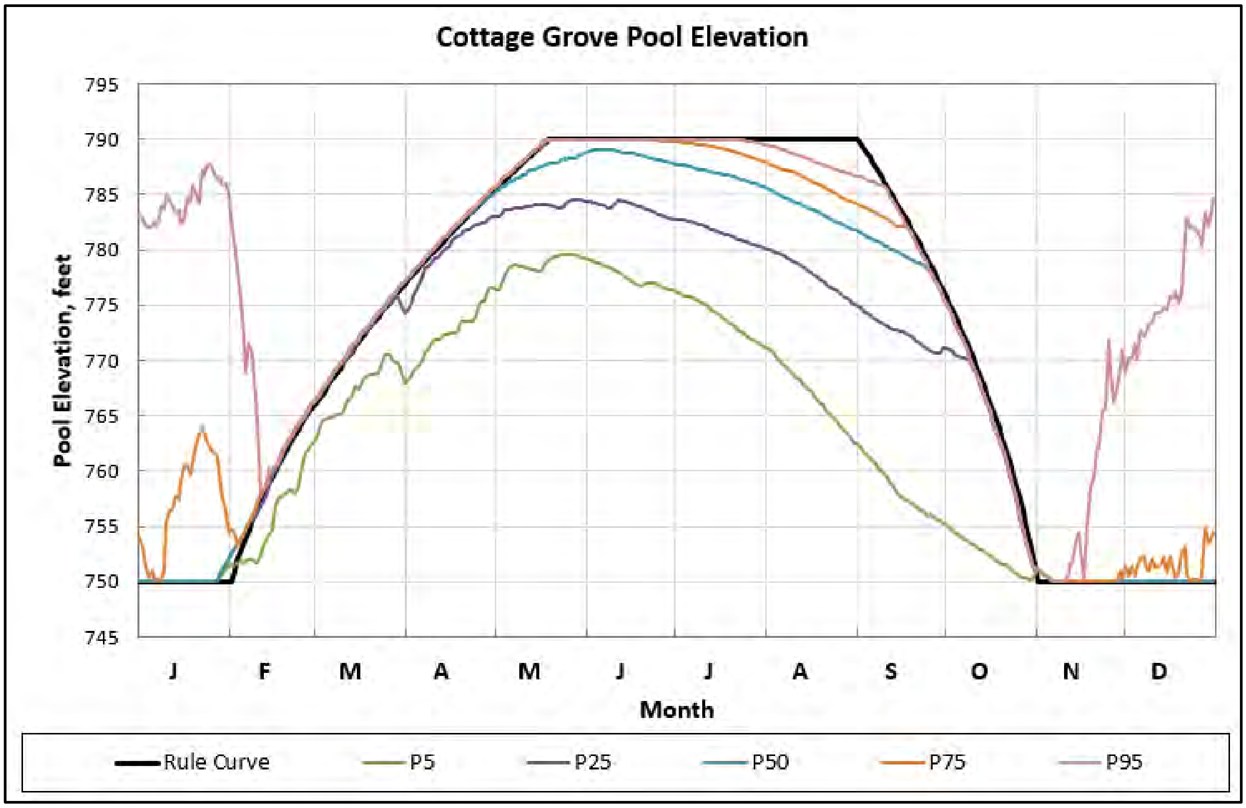



**Figure 3.2-32. NAA Cottage Grove water surface elevation non-exceedance**

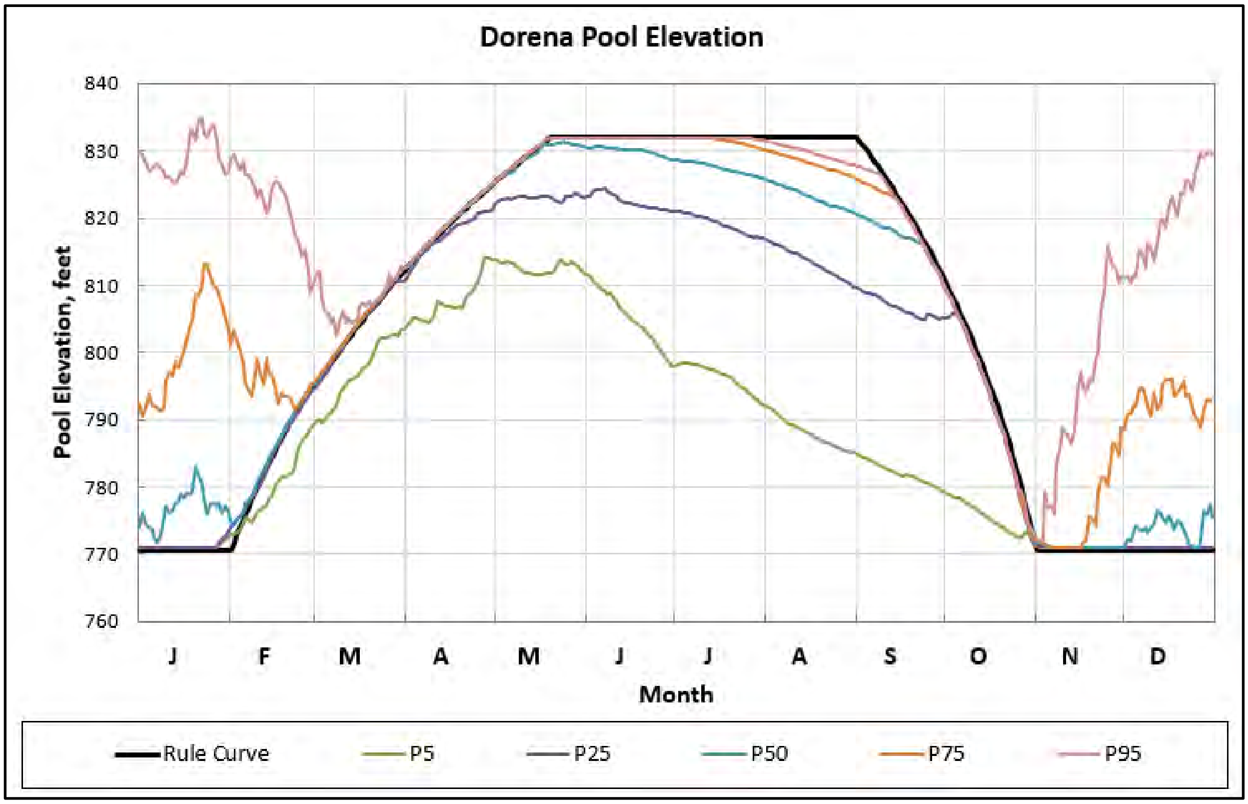



**Figure 3.2-33. NAA Dorena water surface elevation non-exceedance**

The control point for the Coast Fork of the Willamette River is at Goshen (Figure 3.2-34). Since the Coast Fork is lower in elevation and smaller than the Middle Fork, under the NAA, flows would be lower and minimum base flows much lower as a percentage of the average flow. The rise in average flows in October is a function of the reservoirs releasing water in anticipation of flood season. Average flows would drop at the beginning of November as Cottage Grove and Dorena generally get to minimum conservation pool at that time and stop releasing accumulated storage.

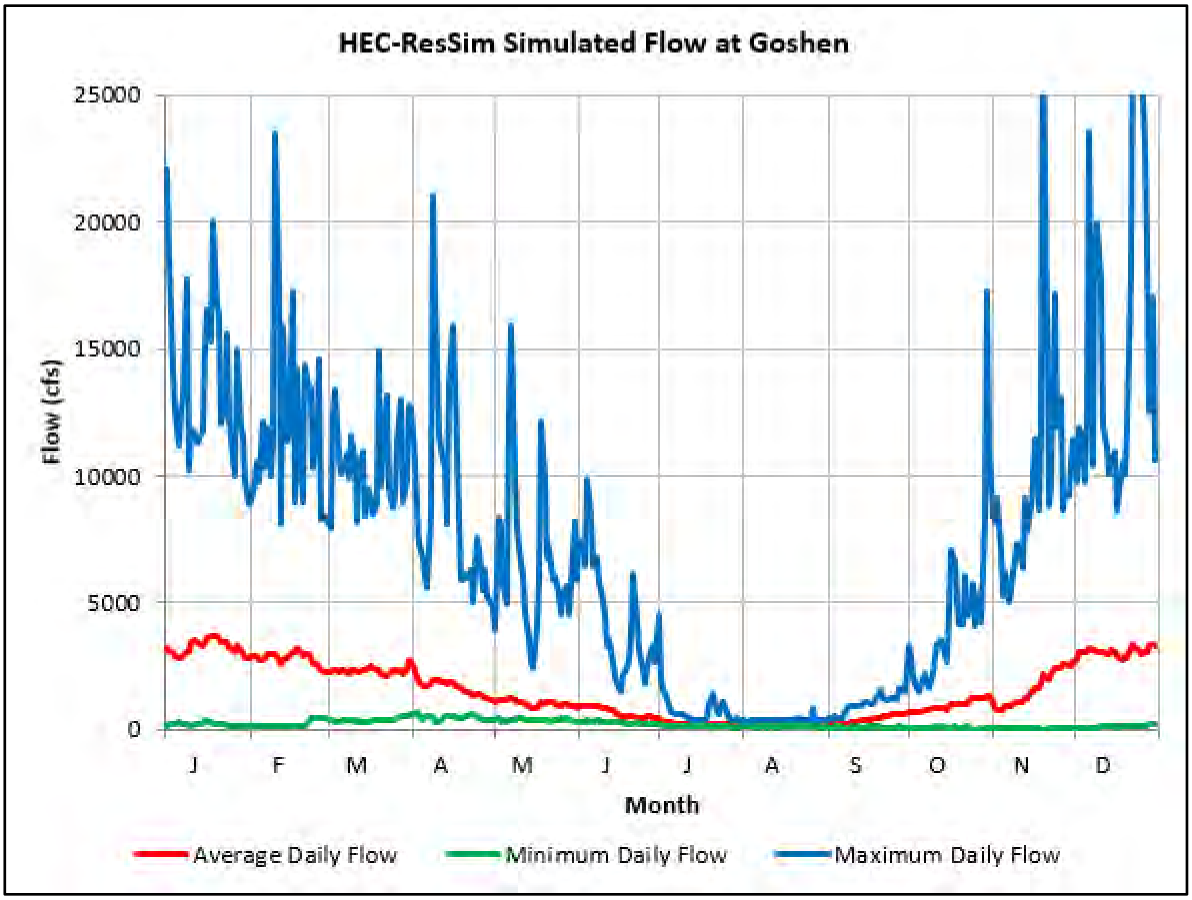



**Figure 3.2-34. NAA Coast Fork of the Willamette at Goshen daily minimum, average, and maximum flows**

*3.2.2.3.6 Mainstem Willamette River*

The 2008 NMFS BiOp set minimum flow targets for the Willamette River at Albany (Figure 3.2-35) and Salem (Figure 3.2-36). The targets shown on both charts are the values set in Abundant and Adequate water years. Deficit years have lower flow targets – shown in the Salem figure – and insufficient years are a sliding scale in between. Flow target determination is set in cooperation with the WATER committee as set forth in the BiOp criteria. Across the inflow dataset's 1935 to 2019 period of record there are:

- 45 Abundant water years
- 26 Adequate water years
- 7 Insufficient water years
- 6 Deficit water years

Since USACE seeks to meet the BiOp targets during summer and fall conservation season as long as possible, the average flow in these months under the NAA would be very close to this minimum flow. Releasing flows above the target would increase the risk of falling below the target later in each water year.

Both the Albany and Salem figures exclude the maximum flood season flows due to show more detail in the lower flow summer season.

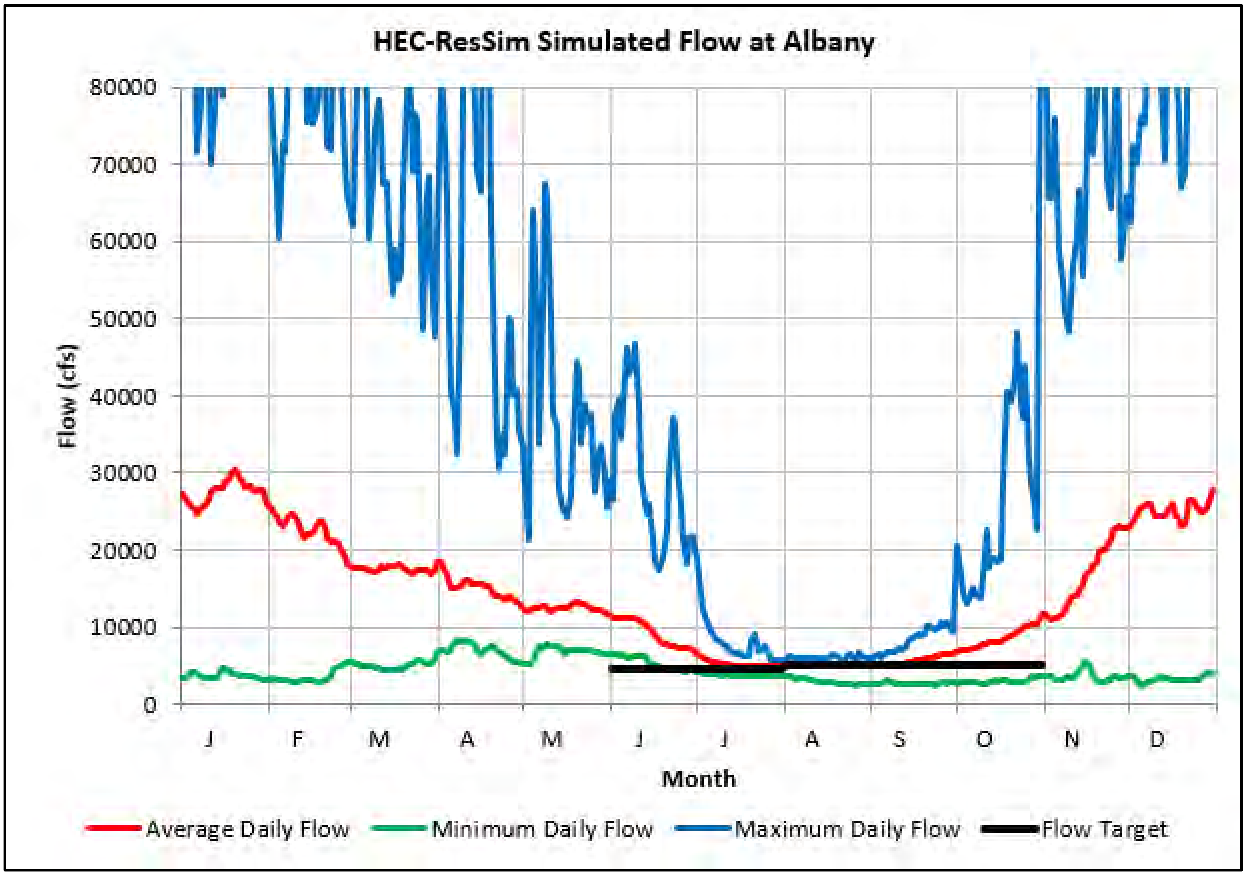



**Figure 3.2-35. NAA Willamette River at Albany daily minimum, average, maximum and BiOp target flows**

The minimum flow line would be well below the target at both Salem and Albany. Since this line represents the minimum on that date across all water years, no single water year is below the BiOp targets for as long. The NAA is below the baseline BiOp target during the driest years for most of the summer and fall as the WATER committee revises these targets lower based on available storage. There is not adequate stored water to fully supplement basin-wide low flows and therefore mainstem flows would not meet the baseline target at either Albany or Salem during dry years. Refer to the biological model section for more information on the flow regime's effect on fish survival.

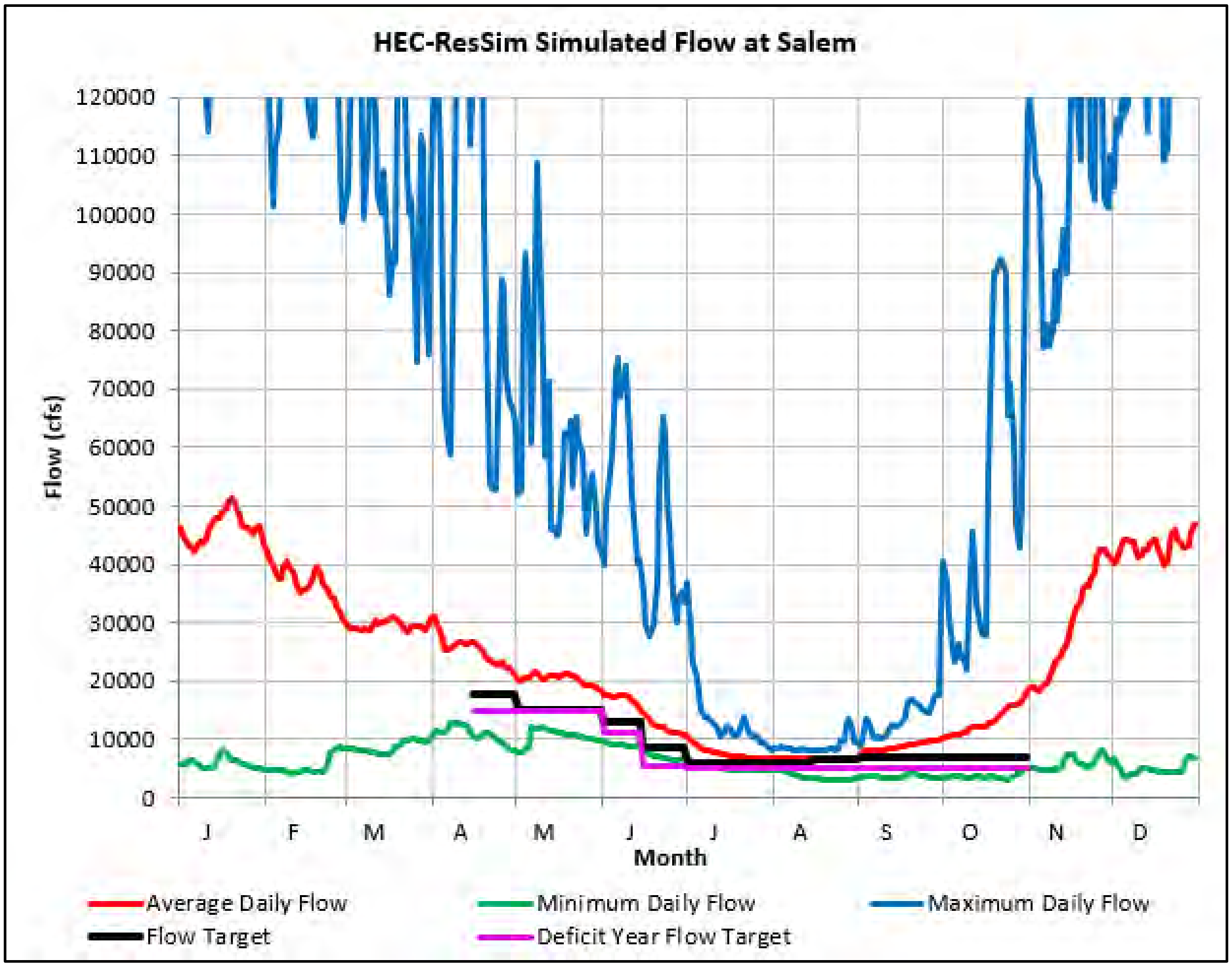



**Figure 3.2-36. NAA Willamette River at Salem daily minimum, average, maximum and BiOp target flows**

### *3.2.2.3.7 Climate Change*

The WVS will likely experience increasing wintertime flow volumes in the future. Some flood magnification (increased severity during flood season) is also likely. Because the WVS system storage will remain about the same, it's likely that FRM operations will face future challenges. An upward shift in median future project inflows may increase both the average reservoir water surface elevation as well as outflows downstream of the WVS dams. Reservoirs located within higher elevation subbasins, such as Detroit and Cougar, are likely to see higher rainfall and runoff volumes in the winter. Higher projected temperatures in the future would mean less snowpack than currently experienced. A lower snowpack would also contribute less to overall spring flows as the snowpack melts. Lower elevation subbasin projects such as Fern Ridge and Cottage Grove, with little or no snowpack, are projected to experience higher wintertime flow volumes, but similar peak runoff timing compared to historical baselines.

Increased variability in the spring shoulder months, drier hotter summers, and lower summer baseflow are the most impactful climate change factors affecting conservation season operations. Decreasing spring inflow may result in less reliable refill. Moreover, increased winter and early spring flows may complicate WVS ability to initiate refill earlier.

Due to decreasing future summer and fall inflows, WVS projects may reach their minimum water surface elevations more frequently. Water surface elevations may decline more rapidly to meet downstream minimum flow targets. The Santiam and Middle Fork subbasins may be drafted more than other WVS reservoirs. With decreasing summer and fall flows, mainstem Willamette flow targets may not be met as often if the larger WVS reservoirs empty more frequently in the future.

#### *3.2.2.4 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Alternative 1 is designed to accumulate water in the WVS reservoirs as much as congressionally authorized and use a greater portion of the total reservoir volume for conservation storage, including portions of pool currently designated as the inactive and power pools. There are changes in regulated hydrology throughout the conservation season, as the goal of Alternative 1 is to fill the reservoirs as often as possible and supply water from storage as long as possible late into the conservation season.

The BiOp outlines minimum releases from WVS dams and sets targets at the downstream control points in the NAA. In Alternative 1, these releases and targets would be reduced to Congressionally authorized minimum flows or a physical operating limit, whichever is greater. The minimum Congressionally authorized flows are lower at Albany and Salem than the BiOp mainstem targets, generally lower across the WVS, and show less seasonal variability. They are also not adaptive, in contrast to the lower-than-baseline flow targets set by the WATER committee in ‘deficit’ and ‘insufficient’ years.

In general, Alternative 1 would have limited effects during an average or wet year in the WRB. The reservoirs would fill during these years while meeting downstream flow targets. Summer flows would sometimes be a bit higher due to the reservoir reaching maximum pool somewhat earlier than normal and therefore passing inflow sooner, but flow differences are minimal compared to the NAA.

Alternative 1 would alter storage in drier than average years, and especially the 25 percent non-exceedance (P25 in the elevation and flow figures) and below years, shifting flow releases from April to June into July through October compared to the NAA. This would miss the current BiOp flow requirements modeled in the NAA more often, but those misses would occur earlier in the year during the April to June period. Later flow targets from July to October are met more frequently due to the additional accumulated stored water.

A more detailed analysis of Alternative 1 by subbasin follows. The reservoir regulation model only considers those measures that affect the water flow volume, location, and timing. Measures that would not affect flow values, such as WTC towers, are not included in this model or the hydrologic processes results.

The shift of stored water releases to a different season would be very noticeable throughout the basin and would bring long term changes to the WRB. Effects from Alternative 1 to hydrologic processes: Major compared to the NAA.

#### *3.2.2.4.1 Santiam Subbasin*

Detroit reservoir (Figure 3.2-37) would fill more often and earlier in the conservation season under Alternative 1. It would also stay higher later in the year throughout water year types. The effect would be most noticeable in the driest years. The P25 line reaches the maximum pool whereas it did not in the NAA. Also, the P05 line does would not reach minimum pool in the fall, whereas in the NAA, higher minimum flows depleted storage and Detroit was forced to only pass inflow when the reservoir reached minimum conservation pool.

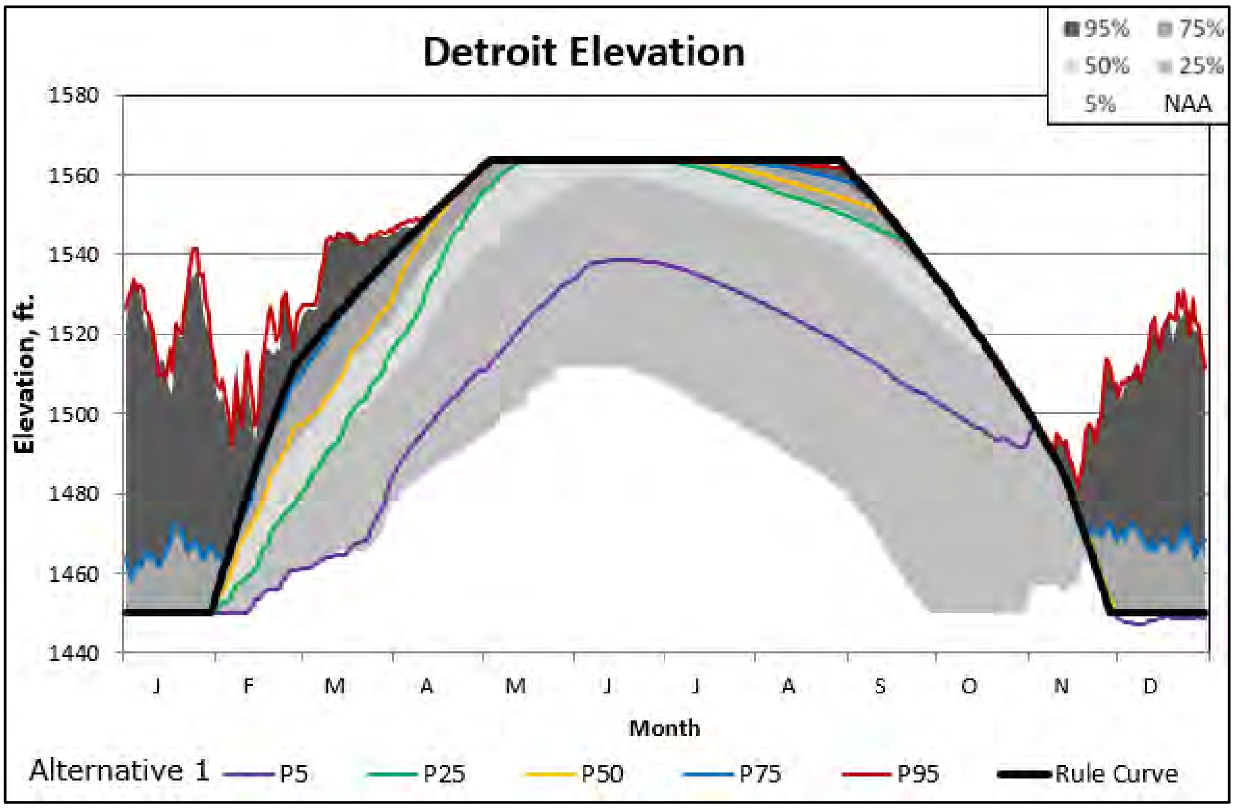



**Figure 3.2-37. Alternative 1 Detroit water surface elevation non-exceedance compared with NAA**

Detroit fills more often and stays higher throughout the summer because the springtime Congressionally authorized minimum flows would be reduced to 1,050 cfs from a variable schedule of 1,000 to 1,500 cfs. Figure 3.2-38 shows this difference starting in March through June. The fall drawdown from a higher typical pool elevation in preparation for winter flood season would drive the increase in flows in September and October. In other words, more remaining stored water would have to be released in the fall to get to minimum conservation elevation compared to the NAA.

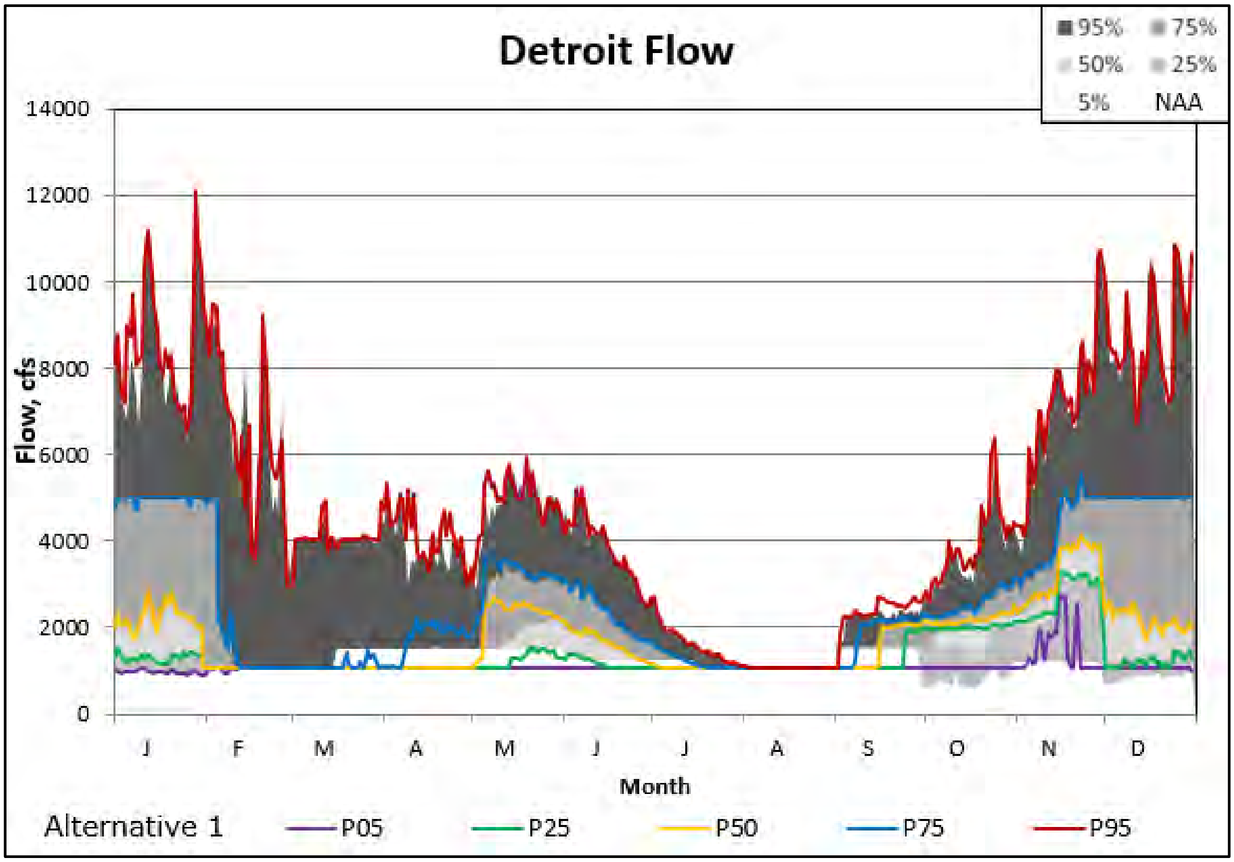



**Figure 3.2-38. Alternative 1 Detroit outflow non-exceedance compared with NAA**

Alternative 1 would have similar effects at Green Peter as it does at Detroit. Figure 3.2-39 shows that the reservoir would stay higher throughout the year and nearly would fill every year – the P05 line comes much closer to the maximum pool than in the NAA. However, this is only a practical difference in the driest years since Green Peter fills in the NAA most of the time. The reduction in these flow minimums means that Green Peter would stay much fuller for longer, able to supply water much later in the year than in the NAA.

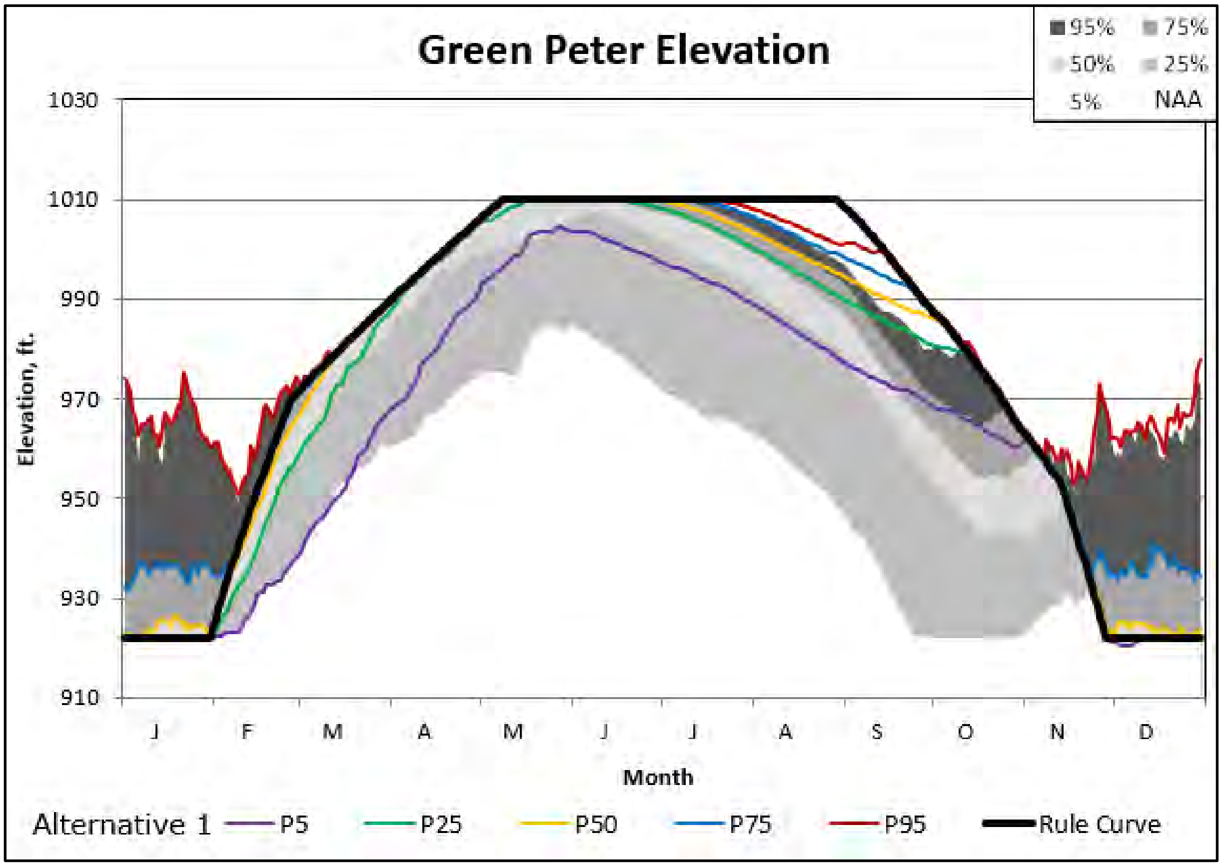



**Figure 3.2-39. Alternative 1 Green Peter water surface elevation non-exceedance compared with NAA**

Downstream of Foster (Figure 3.2-40), which reregulates Green Peter, spring flows would be lower in drier years with the removal of the BiOp targets and about the same in average to wet years. The reduction in target flow on the mainstem would account for the lower flow in September. As Green Peter and Foster draft in preparation for flood season, flows would be higher than in the NAA, as the typical reservoir elevation is higher entering October.

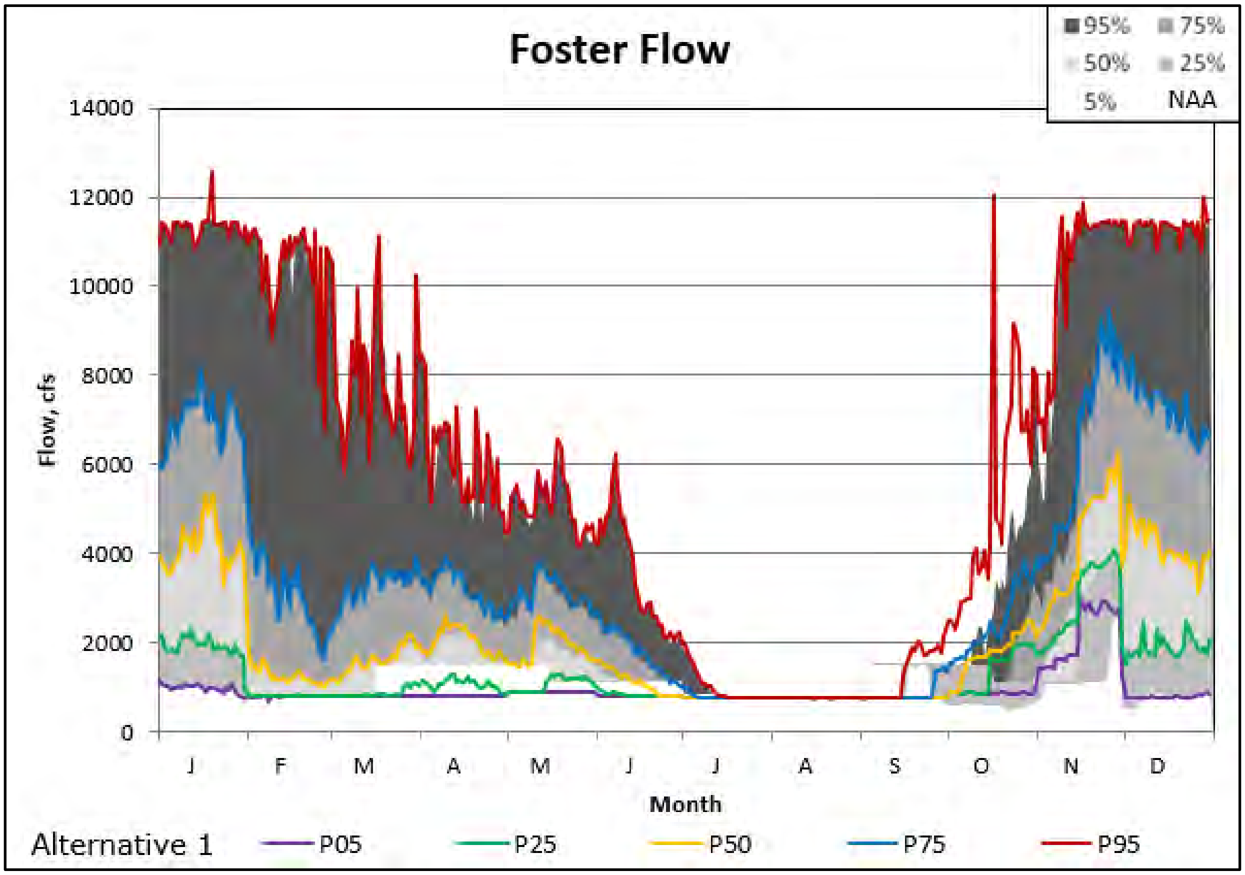



**Figure 3.2-40. Alternative 1 Foster outflow non-exceedance compared with NAA**

At the control point for the Santiam River at Jefferson (Figure 3.2-41), Alternative 1 shows the shift of release of stored water during drier years, while wetter years would remain similar to the NAA. The P05 and P25 lines are below the NAA from March through June with lower minimum flows at Salem. This additional water is stored in the reservoir until the fall drawdown, resulting in higher flows in October.

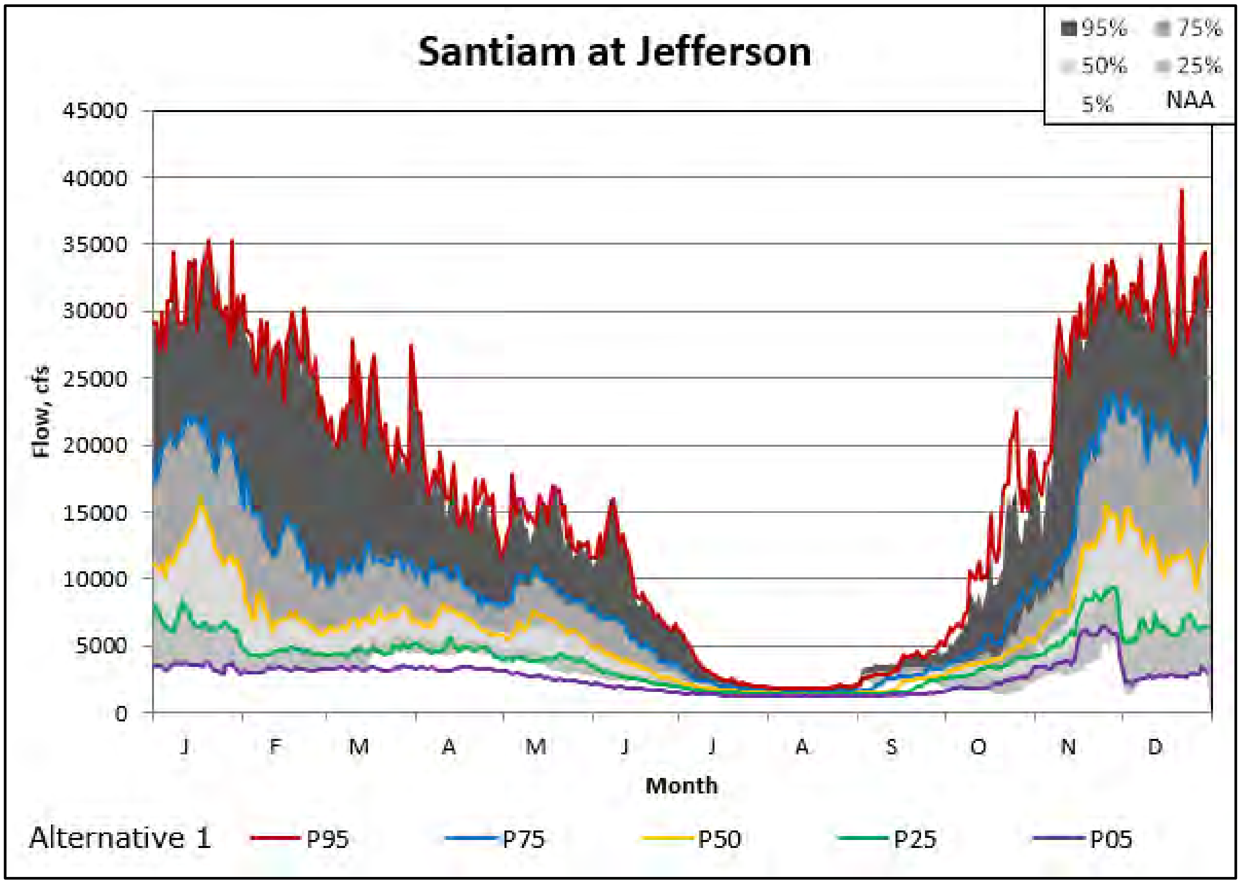



**Figure 3.2-41. Alternative 1 Santiam River at Jefferson flow non-exceedance compared with NAA**

*3.2.2.4.2 Long Tom Subbasin*

As explained in the NAA, Fern Ridge reservoir is operated for recreation and fish and wildlife habitat in the conservation season and typically seeks to maximize the reservoir pool during the summer. Alternative 1 would not appreciably change this goal nor the minimum flow targets and the hydrologic patterns would be nearly the same as the NAA, as shown in Figure 3.2-42. The Alternative 1 downstream control point flows at Monroe show a similar lack of change from the NAA.

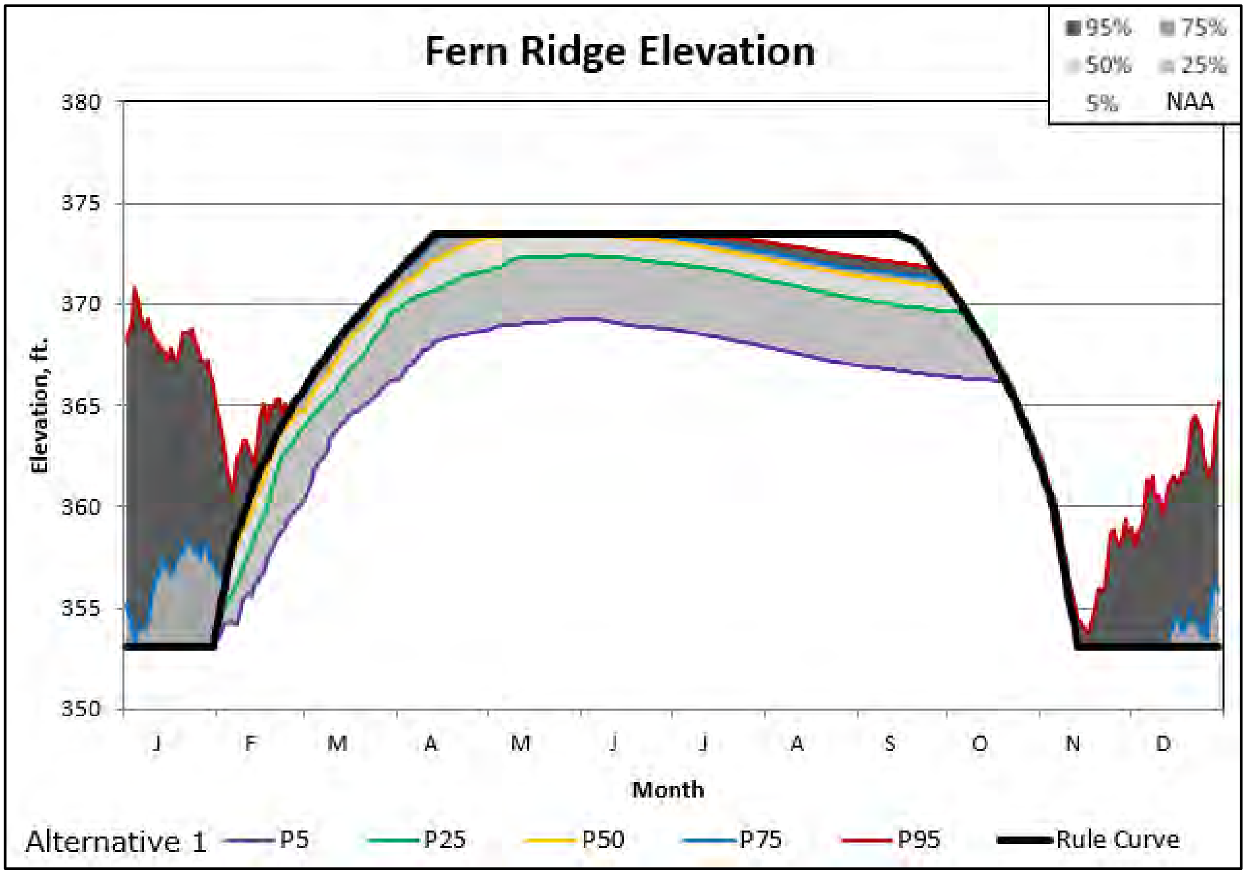



**Figure 3.2-42. Alternative 1 Fern Ridge water surface elevation non-exceedance compared with NAA**

### *3.2.2.4.3 McKenzie Subbasin*

Cougar reservoir would fill more than 75 percent of years with the reduced flow requirements on the mainstem Willamette compared with about 50 percent of years in the NAA, as shown in Figure 3.2-43. There would be more stored water into the summer in all years. Cougar would be able to augment instream flows by using the power pool into the fall of drier years. Blue River reservoir elevations would be similar to the NAA in wetter years and somewhat higher in dry years across Alternative 1.

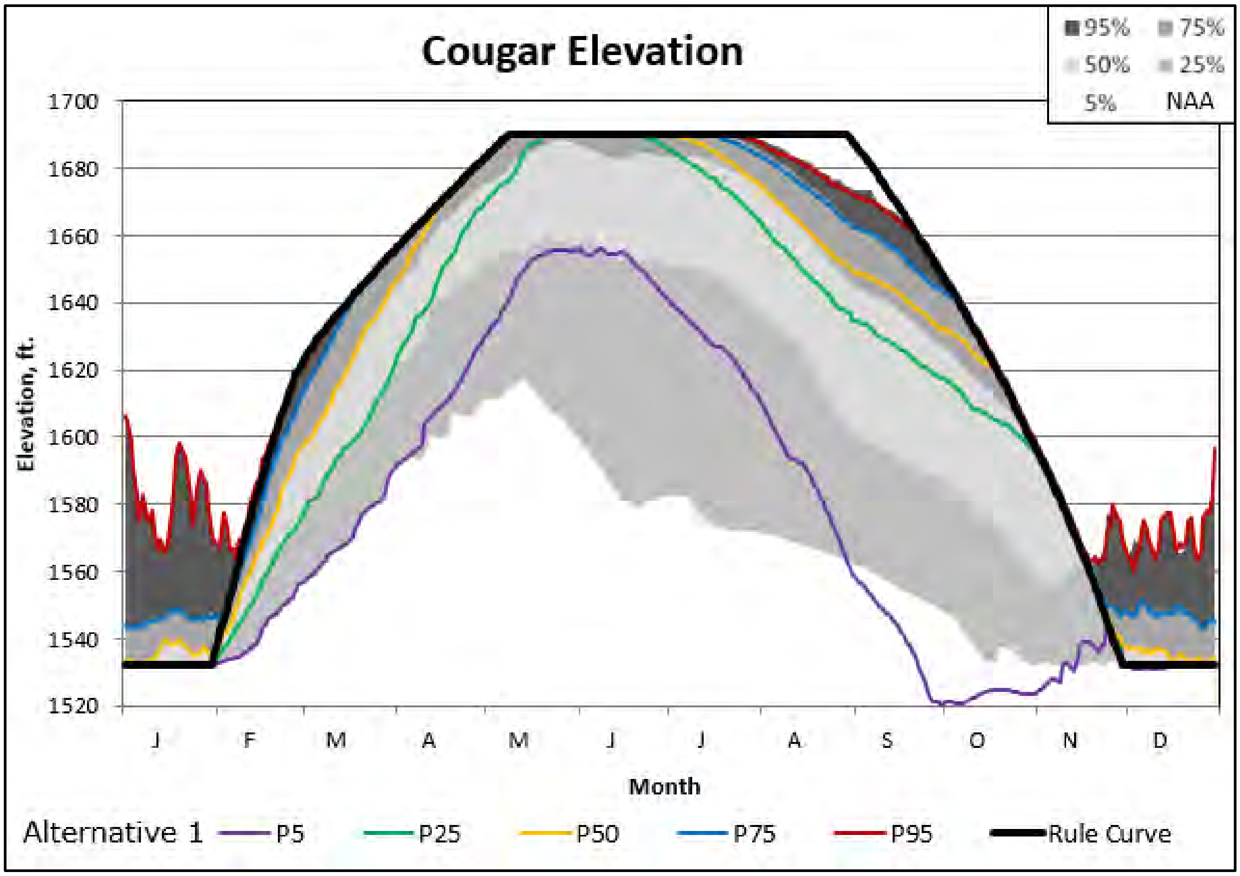



**Figure 3.2-43. Alternative 1 Cougar water surface elevation non-exceedance compared with NAA**

The McKenzie River at Vida (Figure 3.2-44), like other control points, would show a shift of stored water releases from the spring to the summer and fall in the dry years and limited differences in wet years as compared to the NAA. The P05 line would dip below the NAA in October due to the low reservoir elevation at Cougar.

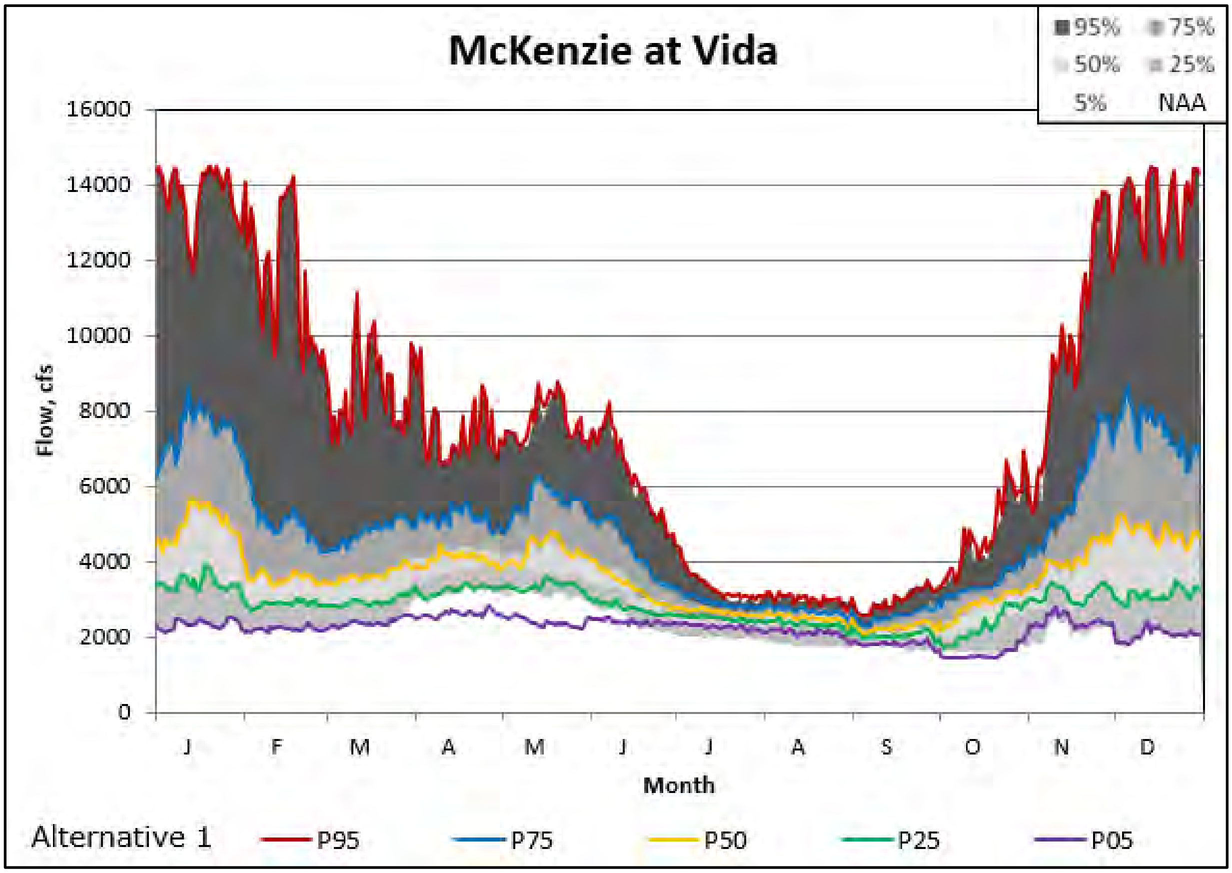



**Figure 3.2-44. Alternative 1 McKenzie River at Vida flow non-exceedance compared with NAA**

### *3.2.2.4.4 Middle Fork of the Willamette Subbasin*

Hills Creek initially would fill more quickly due to the lower downstream flow targets and would stay at similar elevations during wet years (Figure 3.2-45). During dry years, the reservoir would augment instream flows by using the power pool, releasing more water to meet the flow target at Albany. Its capacity would be exhausted in the driest years (P05 line), at which point Lookout Point would supply additional water until it too reaches its minimum power pool elevation in Figure 3.2-46. At the downstream control point at Jasper (Figure 3.2-47), the dry year water shift would be evident, with lower flows in the spring and higher flows in the summer compared to the NAA.

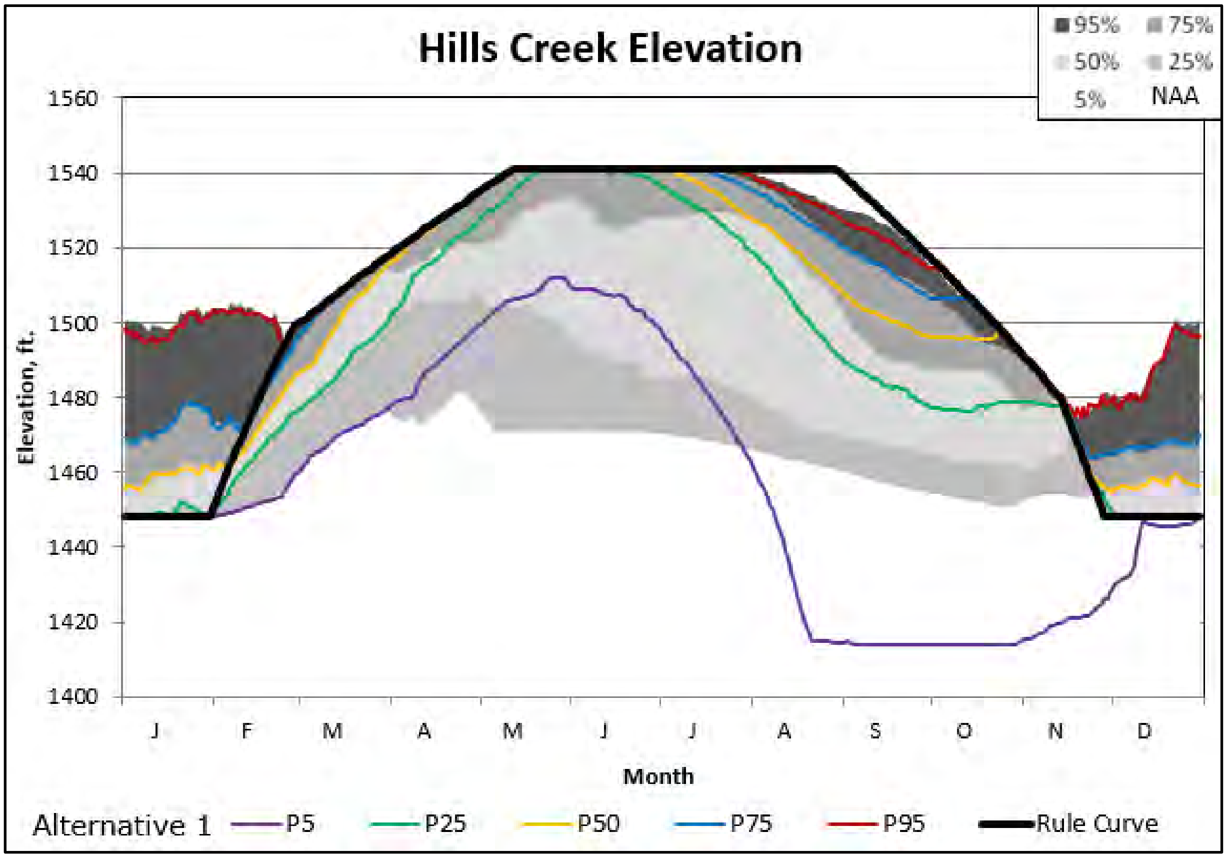



**Figure 3.2-45. Alternative 1 Hills Creek water surface elevation non-exceedance compared with NAA**

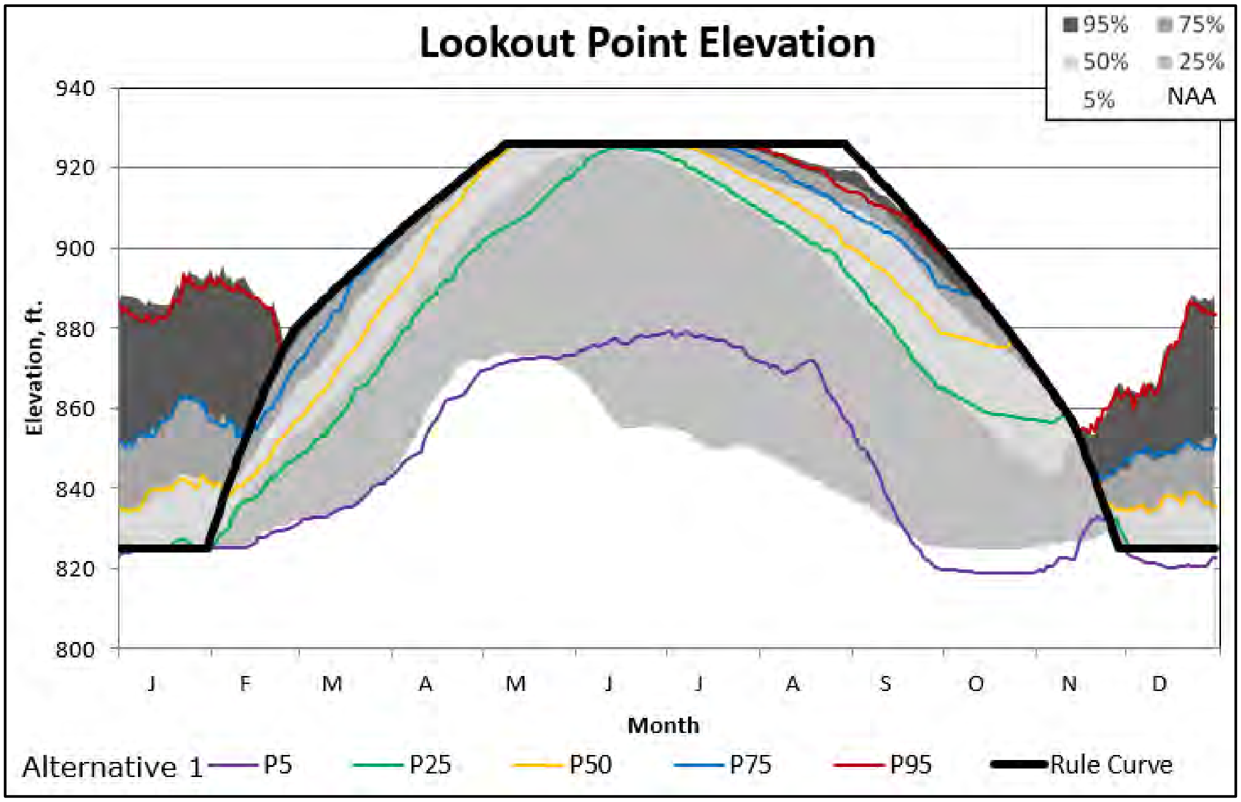



**Figure 3.2-46. Alternative 1 Lookout Point water surface elevation non-exceedance compared with NAA**

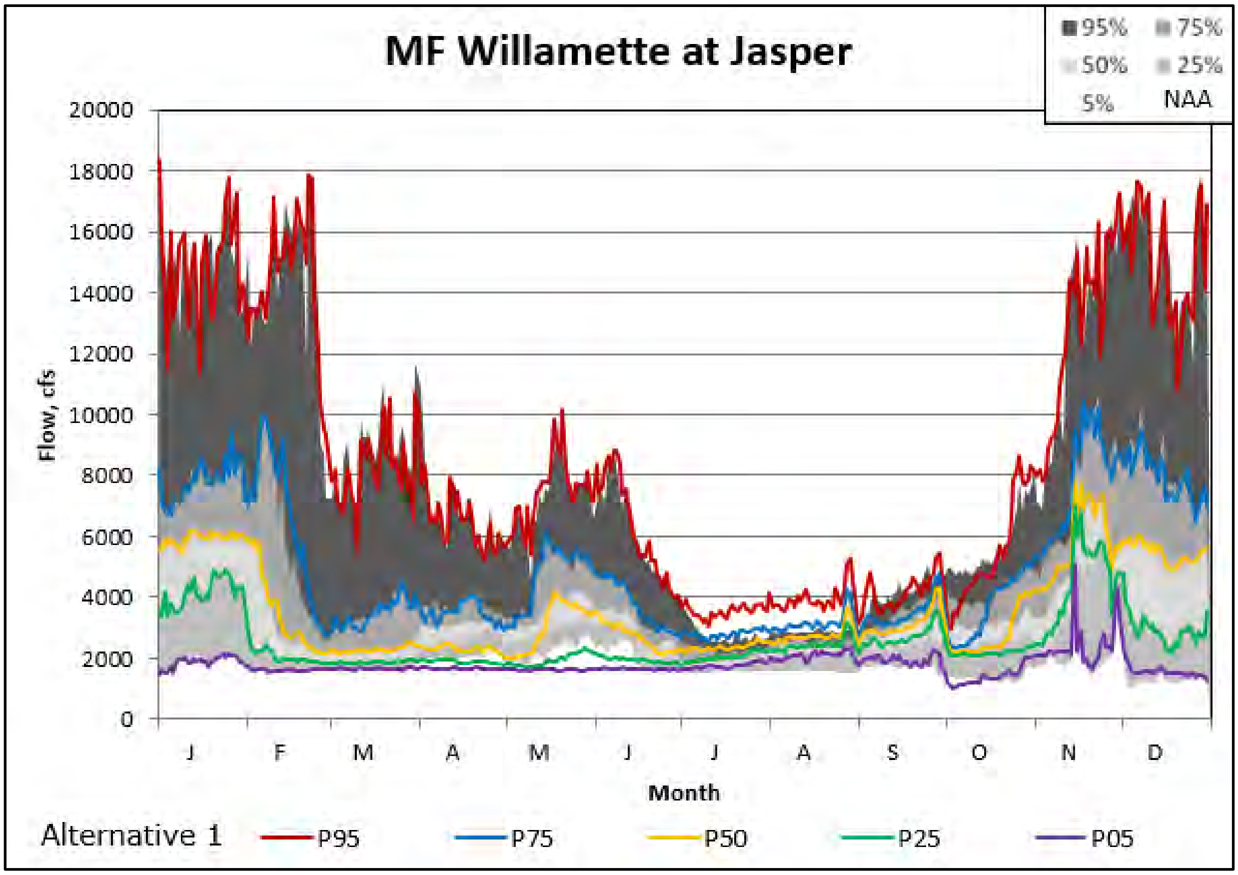



**Figure 3.2-47. Alternative 1 Middle Fork of the Willamette River at Jasper flow non-exceedance compared with NAA**

Fall Creek reservoir elevations (Figure 3.2-48) would be higher and similar for drier and wetter years, respectively, in Alternative 1 as compared to the NAA.

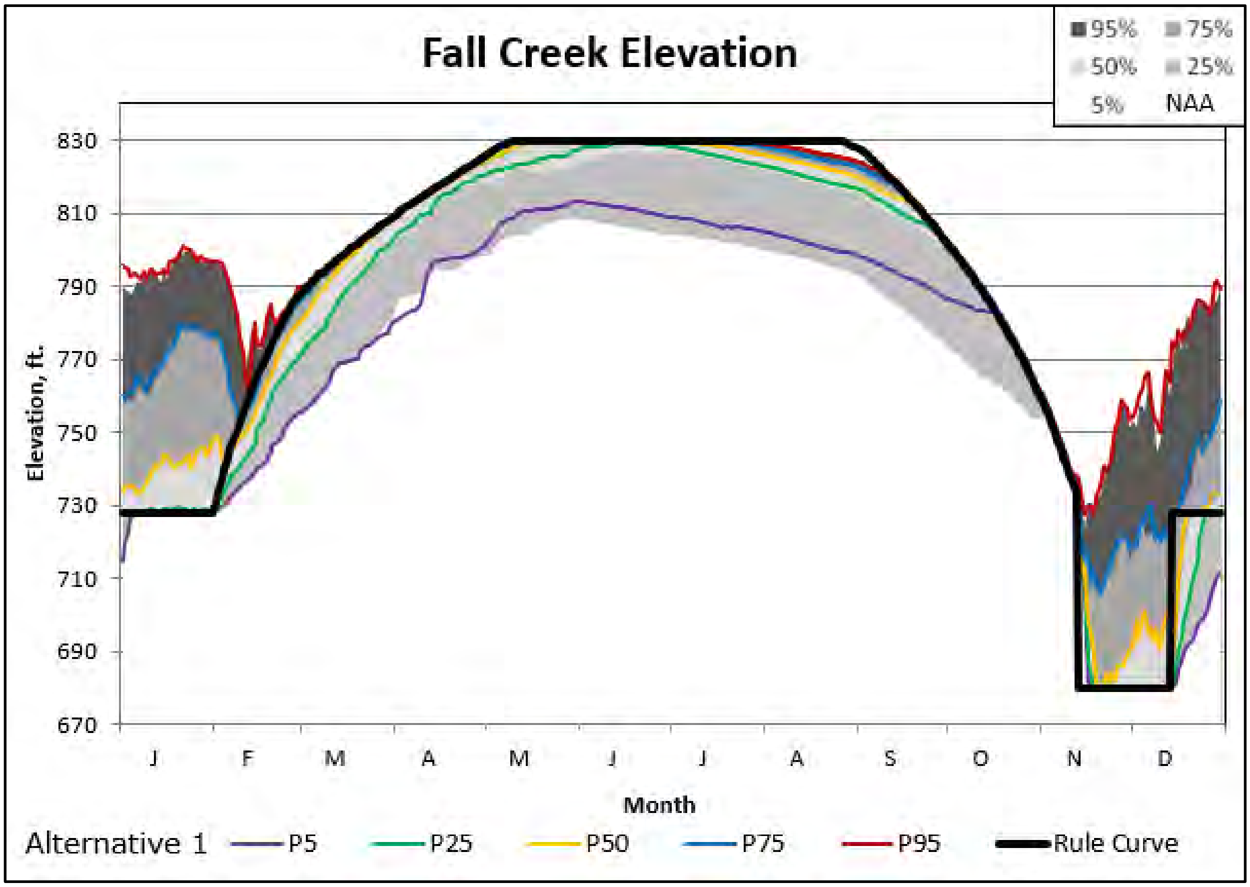



**Figure 3.2-48. Alternative 1 Fall Creek water surface elevation non-exceedance compared with NAA**

### *3.2.2.4.5 Coast Fork of the Willamette Subbasin*

For Alternative 1, the Coast Fork subbasin would also store more water in the spring and release it during the summer and fall during dry years and would be generally similar to the NAA in wet years. Reservoir elevations would be higher at both Dorena (Figure 3.2-49) and Cottage Grove (Figure 3.2-50) for Alternative 1, except in November and December of the driest years when the reservoirs would be augment instream flows by using the inactive pool. Figure 3.2-51 shows the control point at Goshen. Since the pools would stay higher throughout the summer, more water would be released during September and October compared to the NAA.

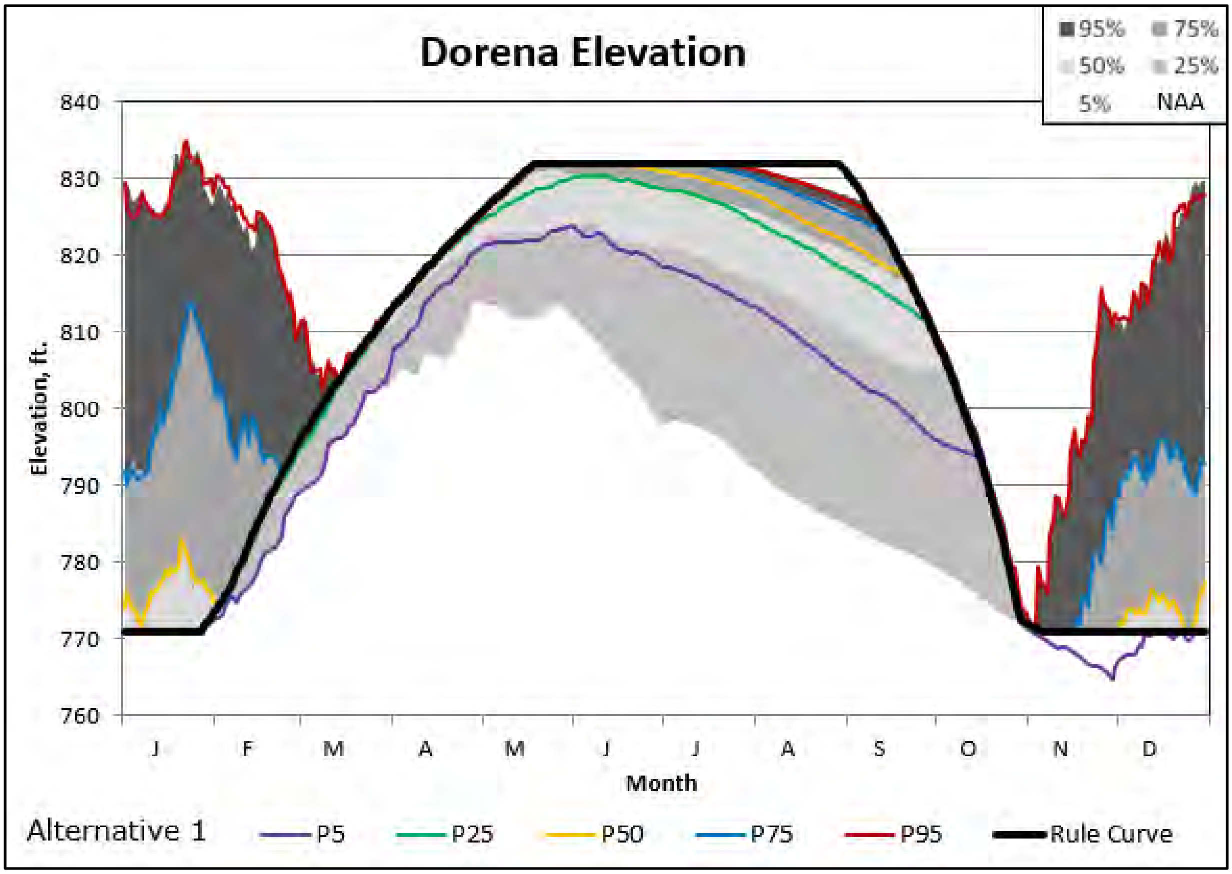



**Figure 3.2-49. Alternative 1 Dorena water surface elevation non-exceedance compared with NAA**

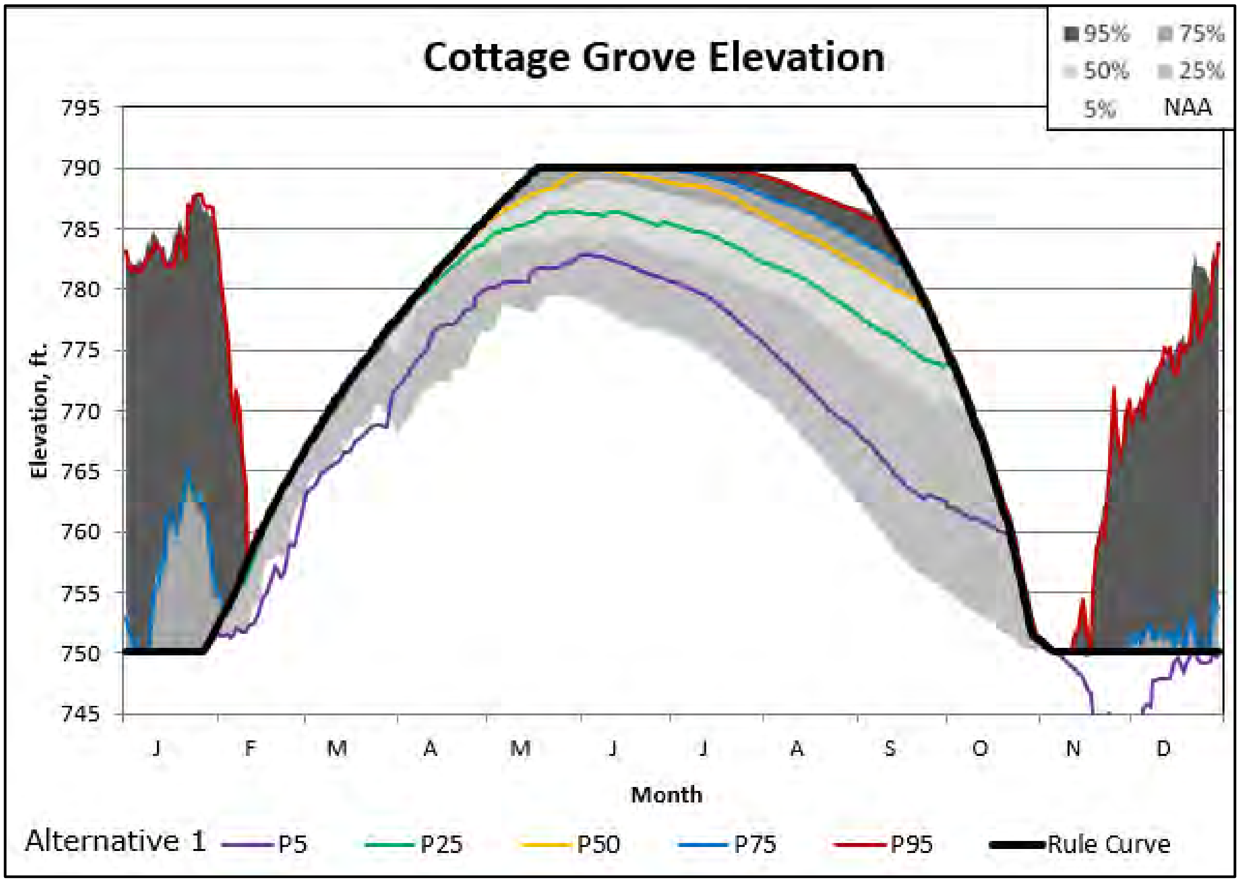



**Figure 3.2-50. Alternative 1 Cottage Grove water surface elevation non-exceedance compared with NAA**

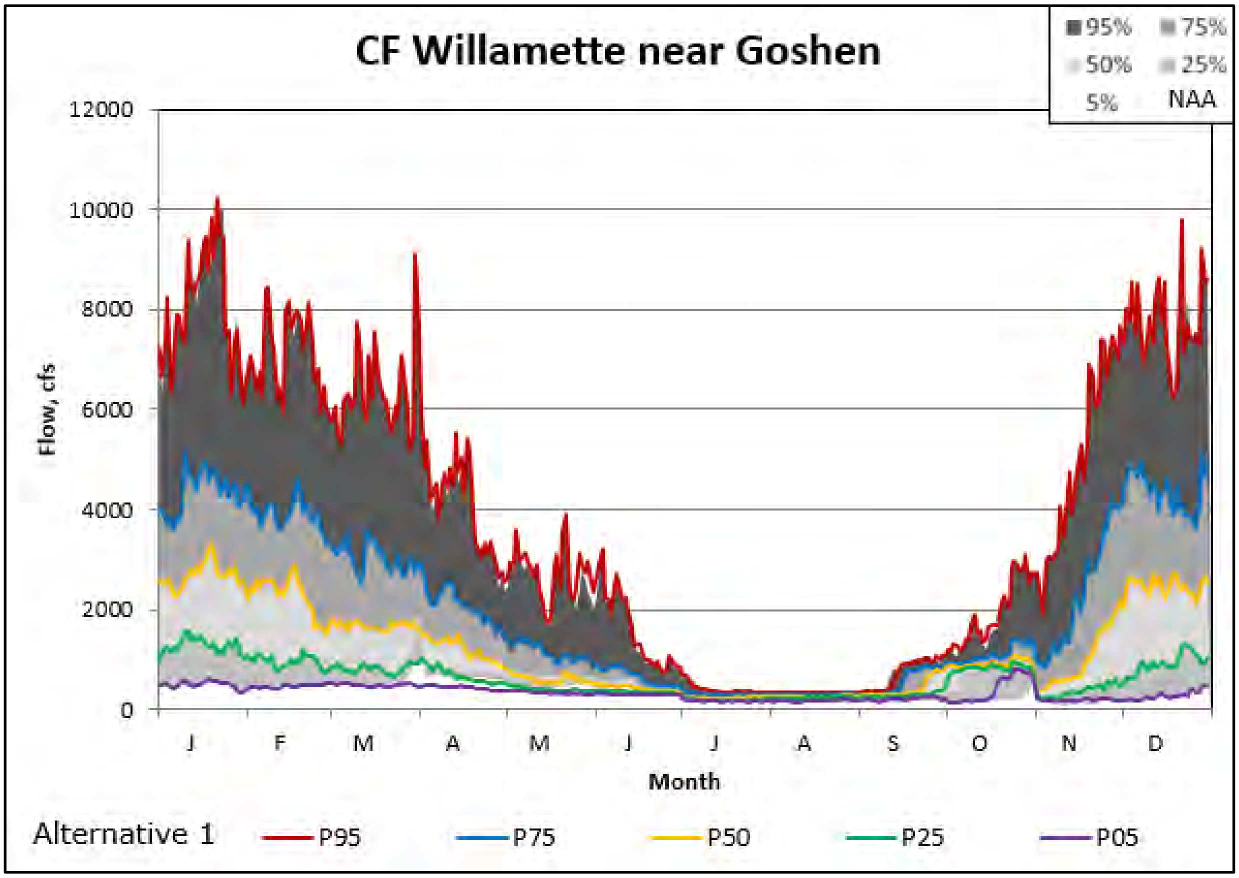



**Figure 3.2-51. Alternative 1 Middle Fork of the Willamette River at Goshen flow non-exceedance compared with NAA**

### *3.2.2.4.6 Mainstem Willamette River*

Alternative 1 would alter the regulated hydrology of the mainstem Willamette River control points during the drier years through the reducing minimum flows to the Congressionally authorized minimum flows. Since higher flows would be generally above these minimums as a matter of course, there would be limited impact to the average and wet years. The P05 and P25 lines would be well below their NAA counterparts from April to June at both Albany and Salem (Figures 3.2-52 and 3.2-53, respectively), with the Congressionally authorized minimum flows lower than the NAA BiOp targets at Salem much more frequently. During dry years, the summer and fall flows would be above the NAA BiOp targets until the driest Octobers, when the Middle Fork reservoirs would exhaust their stored water. The Congressionally authorized minimum flows in Alternative 1 have a lower total volume than the baseline BiOp requirements from the NAA but are not flexible based on expected annual water supply.

Increased flows during the wettest summers, the P95 line, would be due to the reservoirs filling earlier in the year and passing more inflow while at the top of the rule curve compared to the NAA.

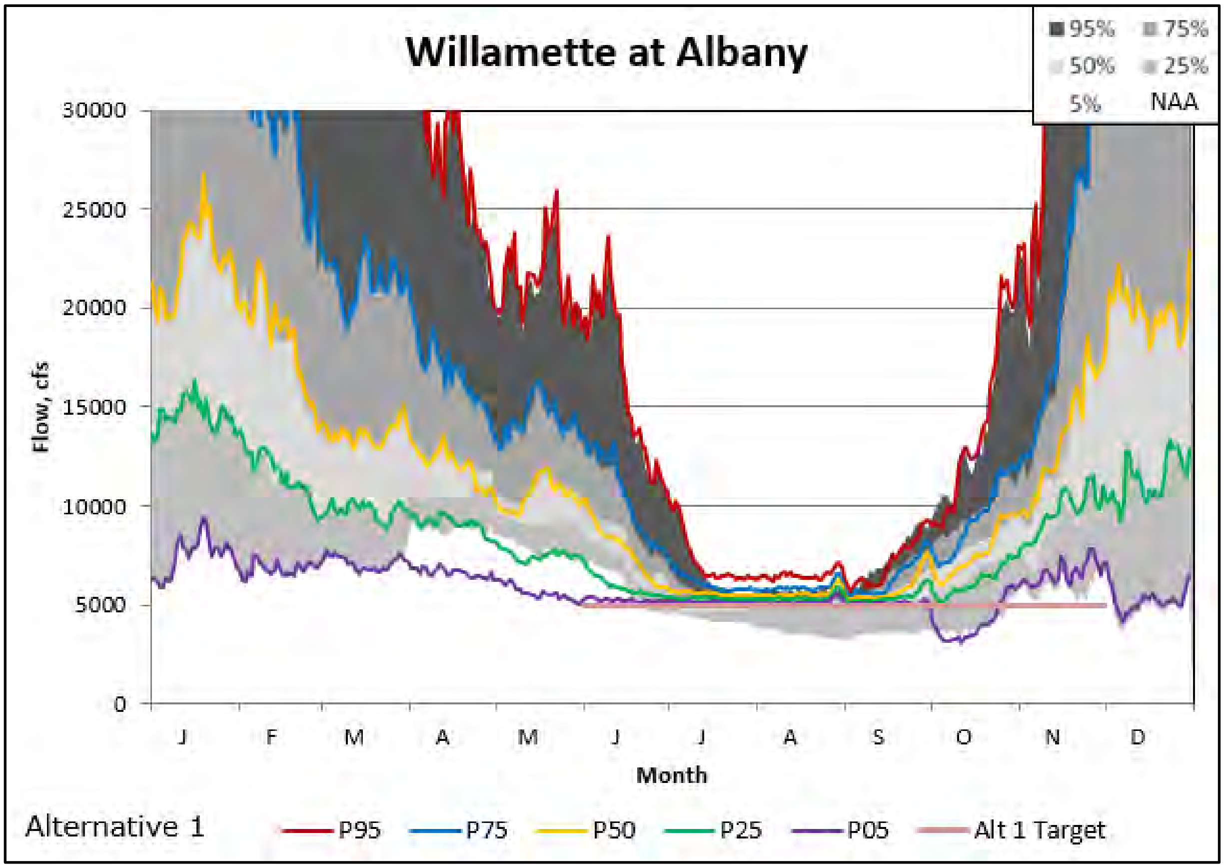



**Figure 3.2-52. Alternative 1 Willamette River at Albany flow non-exceedance compared with NAA**

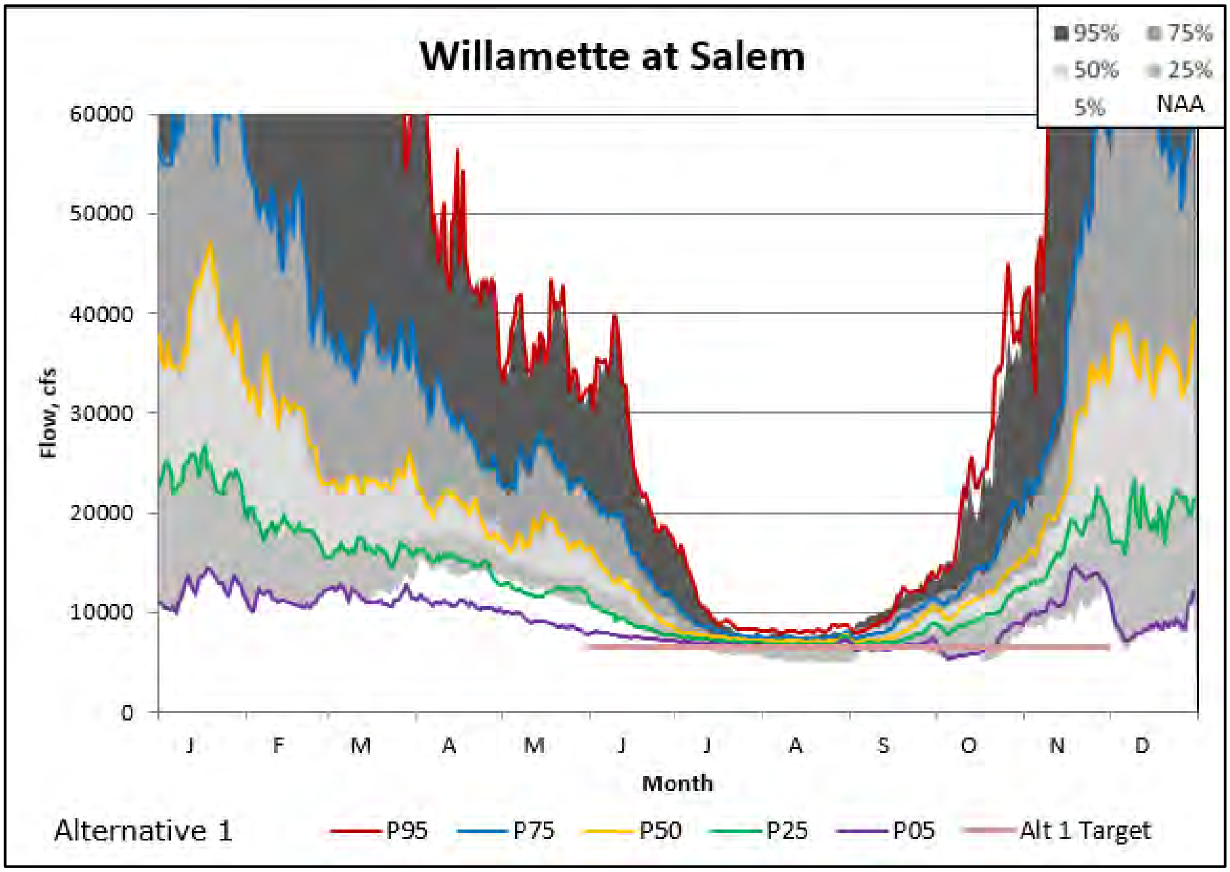



**Figure 3.2-53. Alternative 1 Willamette River at Salem flow non-exceedance compared with NAA**

### *3.2.2.4.7 Climate Change*

The WVS will likely experience increasing wintertime flow volumes in the future. Some flood magnification (increased severity during flood season) is also likely. Because the WVS system storage will remain about the same, it's likely that FRM operations will face future challenges. An upward shift in median future project inflows may increase both the average reservoir water surface elevation as well as outflows downstream of the WVS dams. Reservoirs located within higher elevation subbasins, such as Detroit and Cougar, are likely to see higher rainfall and runoff volumes in the winter. Higher projected temperatures in the future would mean less snowpack than currently experienced. Lower snowpack would also reduce spring volume as the snow melts. Lower elevation subbasin projects such as Fern Ridge and Cottage Grove, with little or no snowpack, are projected to experience higher wintertime flow volumes, but similar peak runoff timing compared to historical baselines.

Since the Congressionally authorized minimum flows are lower, the reservoirs can store more water during conservation season as compared to the NAA. However, reservoirs will have to use more of this stored water to meet downstream flow targets with projected increased variability in the spring shoulder months, drier hotter summers, and lower summer baseflow. Therefore, reservoirs are projected to have lower water surface elevations compared to the baseline. Most reservoirs in Alternative 1 baseline only rarely reach minimum elevation in the fall, meaning they have additional water to continue to augment downstream flows as compared to the NAA. As projected late spring, summer, and fall flows decrease in the future, the WVS could supply more of the additional stored water to augment stream flows. The lowest reservoir water surface elevations will occur in the driest years, which would be drier than the WVS currently encounters, as the reservoirs are drafted more to meet downstream flow targets. Climate change effects, and potential implications as discussed above, draw on the climate change projection and trend information provided in the climate change appendices.

#### *3.2.2.5 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam)*

Alternative 2A would shift the release of stored water from the spring to the summer and fall, most prominently in dry years. The "Integrated Temperature and Habitat Flow Regime" would replace the 2008 NMFS BiOp in the NAA. Briefly, this would modify the base flow targets at a WVS reservoir if it is at more or less than 90 percent of rule curve elevation. Flows would be reduced within a range down to minimums needed for fish survival when reservoirs are under the 90 percent threshold. While these minimums would be less the BiOp targets in the NAA, these would be adaptive within a water year and could return to levels that are actually higher than the BiOp flows if reservoir levels are high.

At the mainstem Willamette control points – Albany and Salem – flow targets would be reduced to 4,500 and 5,000 cfs, respectively. The higher BiOp targets, particularly in the spring and early summer, are designed to help migrating fish and keep the river from getting too hot, so substantially more water would be added in the spring. As a replacement, the integrated temperature and habitat flow regime would require additional flow based on the air temperature, with total flow minimum at Salem ranging from 5,900 cfs to 19,800 cfs. This would allow the WVS to store additional water when it is not needed to keep the river, and the fish in the river, cool.

Alternative 2A would alter storage in drier than average years, and especially the 25 and 5 percent non-exceedance (P25 and P05 in the figures) years, shifting flow releases from April to June into July through October. This would result in lower flows than the NAA earlier in the year during the April to June period. Flows later in the summer and fall, from July to October, would be higher than the NAA due to the additional accumulated stored water. Compared to the NAA, the flow targets would be similar or somewhat lower across the WVS, so reservoir elevations would be somewhat higher than the NAA.

Green Peter reservoir would have a deeper fall reservoir drawdown in Alternative 2A and the model shows the consequences of it at all downstream control points. Specifically, the deeper fall reservoir drawdown means there would be more flow in the late summer and early fall in the South Santiam, Santiam, and Willamette downstream of the confluence with the Santiam. Refilling the reservoir to minimum conservation pool would also reduce downstream flows by a relatively small amount through about the middle of January in a typical year compared to the NAA.

USACE would construct structural downstream fish passage in Cougar reservoir in Alternative 2A and therefore the spring and fall reservoir drawdowns would not be as deep in Alternative 2B (and Alternative 3B). The maintenance of storage at Cougar would mean that it can supply water downstream similar to the NAA (or Alternatives 1 and 4). Other reservoirs, most notably in the Middle Fork of the Willamette subbasin, would also maintain higher water surface elevations without the need for additional releases to meet downstream flow targets. The WVS would also meet the mainstem Willamette River flow targets more often with higher Cougar storage levels, as compared to the NAA.

Although there are structural actions in Alternative 2A at the WVS dams to aid fish survival, many of these would not affect the flow out of any WVS dam. These would not appear in the reservoir flow model. An example of this is the WTC tower at Detroit, which would allow for greater control of the temperature of the water released from the dam but would not alter the flowrate or outlet used for dam operations. A more detailed analysis of Alternative 2A by subbasin follows.

Lower spring flows in dry years and higher summer flows in nearly all years would have long term effects across the WRB. Effects from Alternative 2A to hydrologic processes: Major compared to the NAA.

#### *3.2.2.5.1 Santiam Subbasin*

Alternative 2A would fill Detroit reservoir more often and narrow the range of reservoir elevations prior to drafting the reservoir for flood season (Figure 3.2-54). The lowest minimum flow of the integrated temperature and habitat flow regime would be smaller downstream of Detroit so the reservoir would be able to fill more often. These lower flow requirements would only apply when the reservoir is below 90 percent full, so would only come into use during drier years. During wetter years, storage would be near the rule curve regardless of the higher flow requirements downstream. Detroit has more volume to supply to downstream targets later in the year, meeting all its immediate downstream flow targets across all years compared to the NAA.

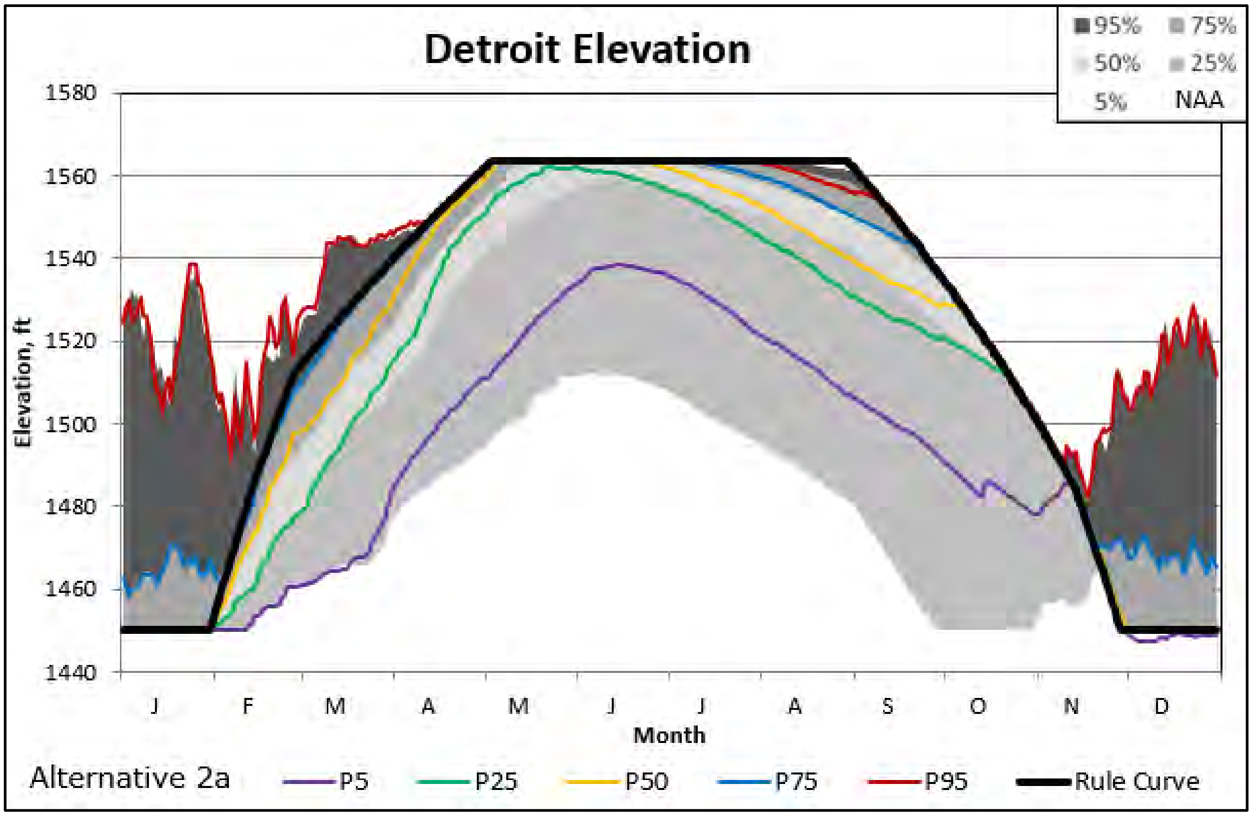



**Figure 3.2-54. Alternative 2A Detroit water surface elevation non-exceedance compared with NAA**

Green Peter reservoir (Figure 3.2-55) would also fill more often during conservation season in Alternative 2A as compared to the NAA, despite implementation of a deeper fall reservoir drawdown. In very dry years, the reservoir elevation would be well below the rule curve through the winter but it would recover to higher levels than the NAA by summer due to the lower integrated temperature and habitat flow regime targets. However, the percentage of time that Green Peter reaches top of conservation storage would remain about the same since all inflow above that level would be released from the reservoir. Lower reservoir levels would be expected throughout the winter flood season, even during the wettest years.

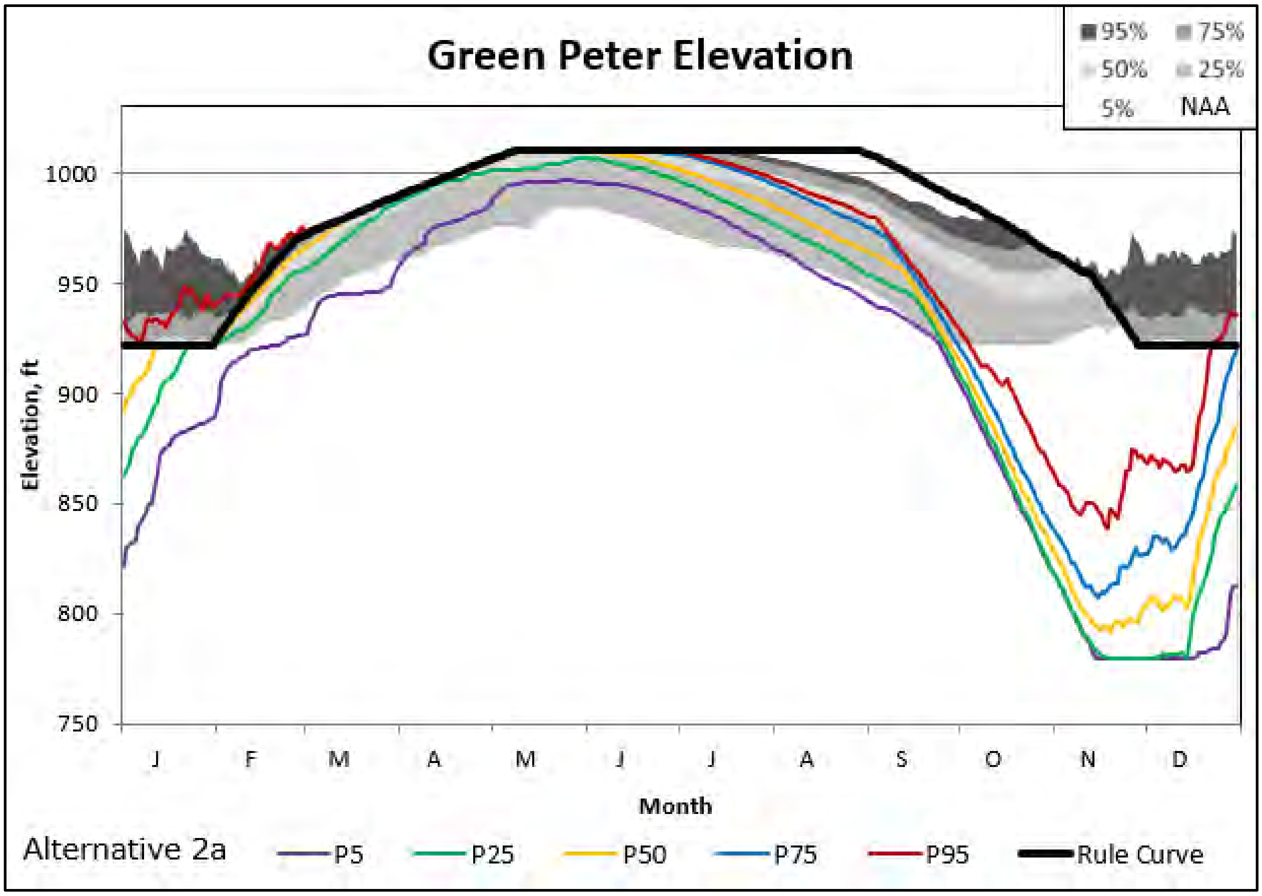



**Figure 3.2-55. Alternative 2A Green Peter water surface elevation non-exceedance compared with NAA**

Outflow from Foster Dam (Figure 3.2-56) would meet the integrated temperature and habitat flow regime targets except in November of very dry years when Green Peter would have already reached the minimum deeper fall reservoir drawdown elevation. The increased flows in September are the result of Green Peter releasing water for the deeper fall reservoir drawdown which does not occur under the NAA. Immediately downstream, winter flows across all but very wet years would be lower. This is also due the Green Peter deeper fall reservoir drawdown, as it holds back water to get back up to minimum conservation pool. Foster Reservoir would seldom deviate from the rule curve for Alternative 2A.

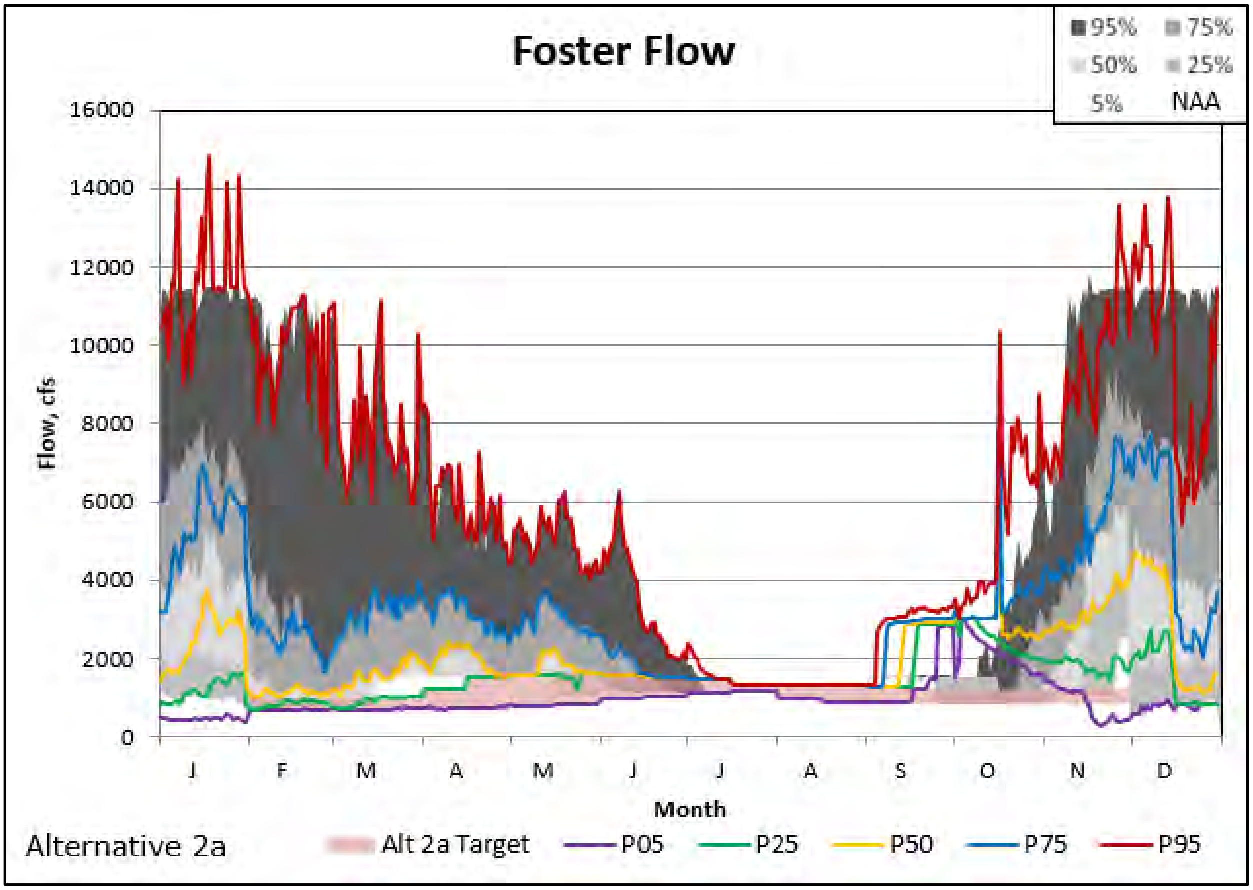



**Figure 3.2-56. Alternative 2A Foster flow non-exceedance compared with NAA**

The Santiam at Jefferson (Figure 3.2-57) would show some of the flow changes at Foster but any potential winter flood management benefits from the deeper fall reservoir drawdown at Green Peter would no longer present. Wet weather flows would be very similar to the NAA during the winter and lower flows are only slightly lower, though these flows would already be well below flood stage. In the spring, lower flows in the driest years would be due to the lower requirements of the integrated temperature and habitat flow regime, both directly downstream of the dams and mainstem flow targets. Detroit, with its higher storage volumes, can supply water throughout the summer, resulting in higher flows than the NAA. The increased flows in September from the Green Peter deeper fall reservoir drawdown would be evident at Jefferson.

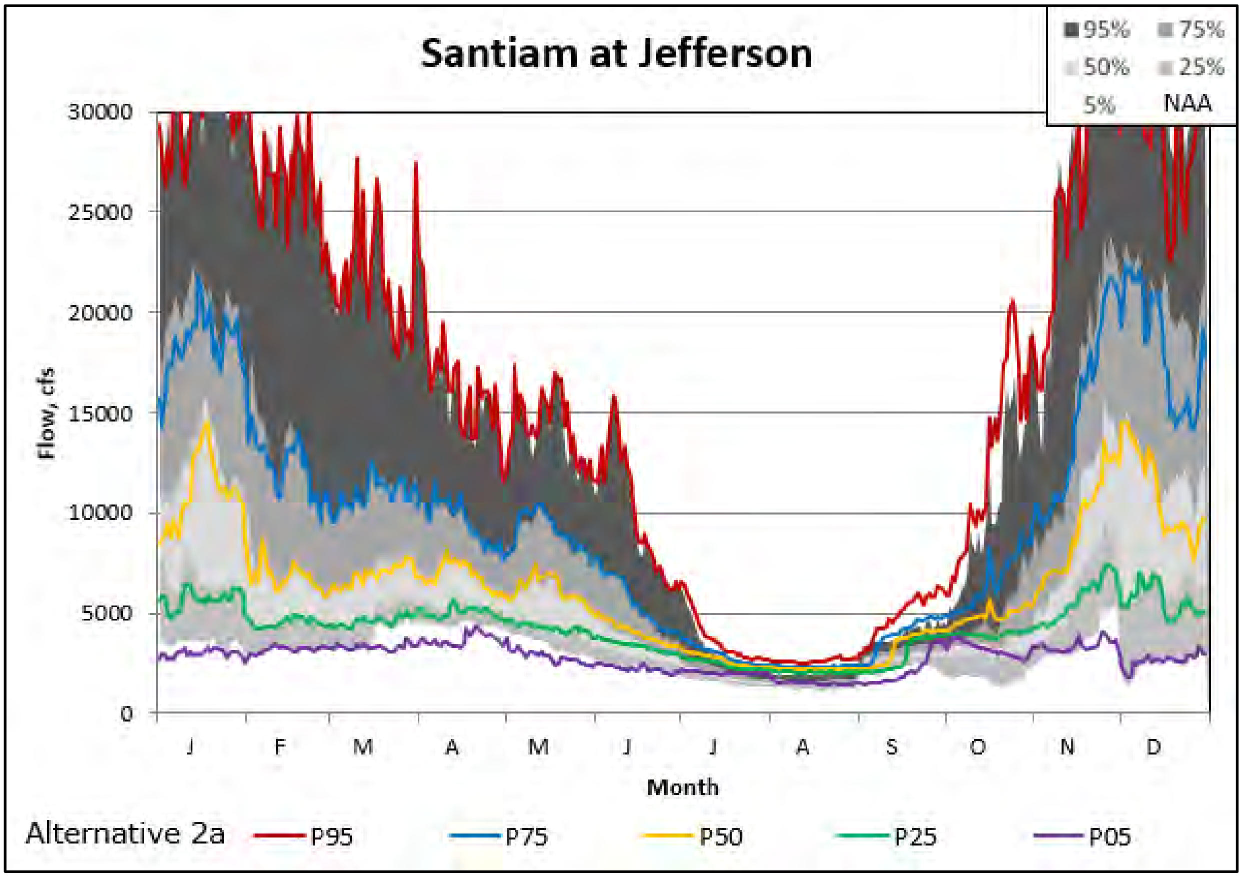



**Figure 3.2-57. Alternative 2A Santiam at Jefferson flow non-exceedance compared with NAA**

### *3.2.2.5.2 Long Tom Subbasin*

As explained in the NAA, Fern Ridge reservoir (Figure 3.2-58) is prioritized for recreation and fish and wildlife habitat in the conservation season and typically seeks to maximize the reservoir pool during the summer. Since Fern Ridge has a large surface area and small volume compared to the other WVS reservoirs, there is limited scope to change its operation and the water surface elevations within Fern Ridge remain nearly the same as the NAA. Downstream flows at Monroe would remain similarly unchanged for Alternative 2A.

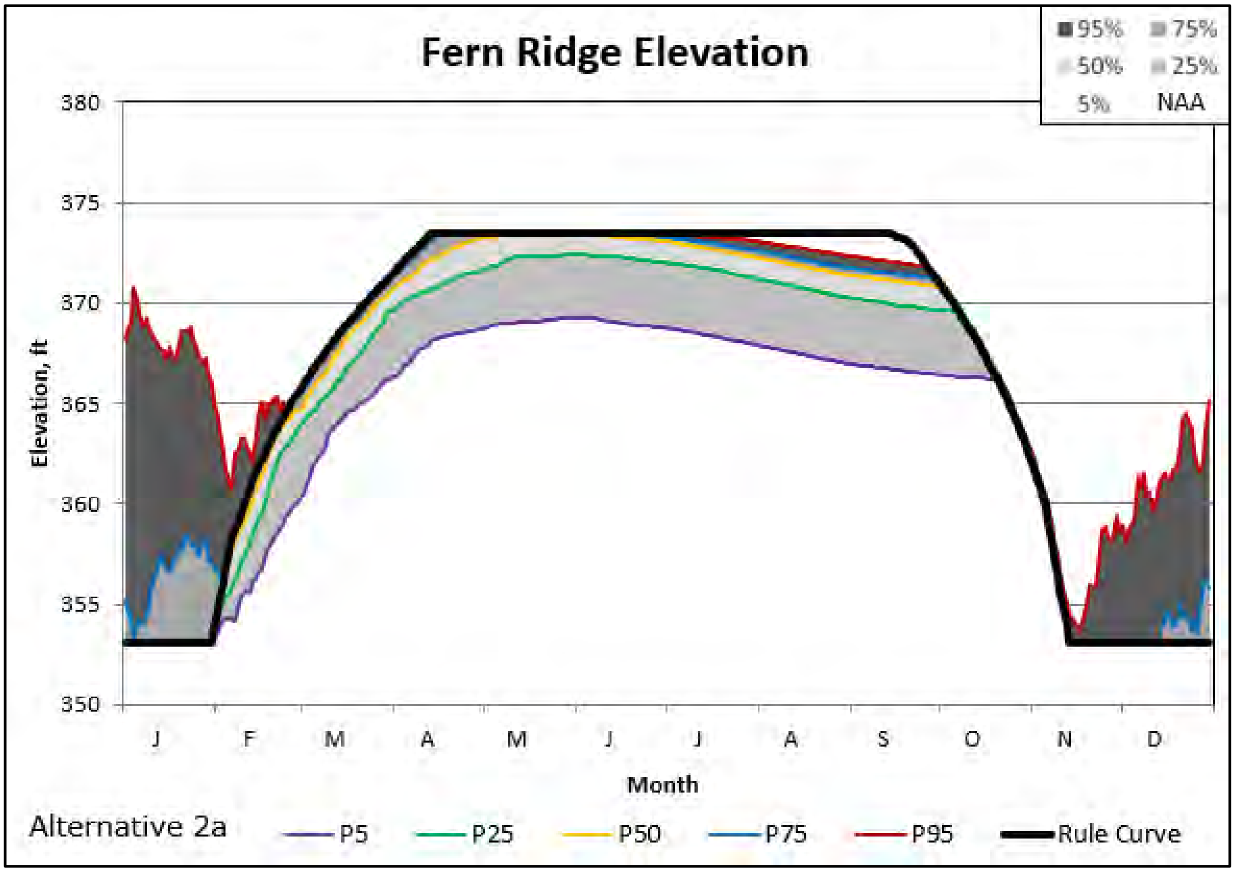



**Figure 3.2-58. Alternative 2A Fern Ridge water surface elevation non-exceedance compared with NAA**

### *3.2.2.5.3 McKenzie Subbasin*

Cougar reservoir (Figure 3.2-59) would fill more often in Alternative 2A and would stay higher in conservation season except in the driest years (P05 line) compared to the NAA. The additional allowance to augment instream flows by using the power pool below minimum conservation storage elevation means that Cougar would be able to meet its integrated temperature and habitat flow regime target directly downstream of the dam even in those driest years.

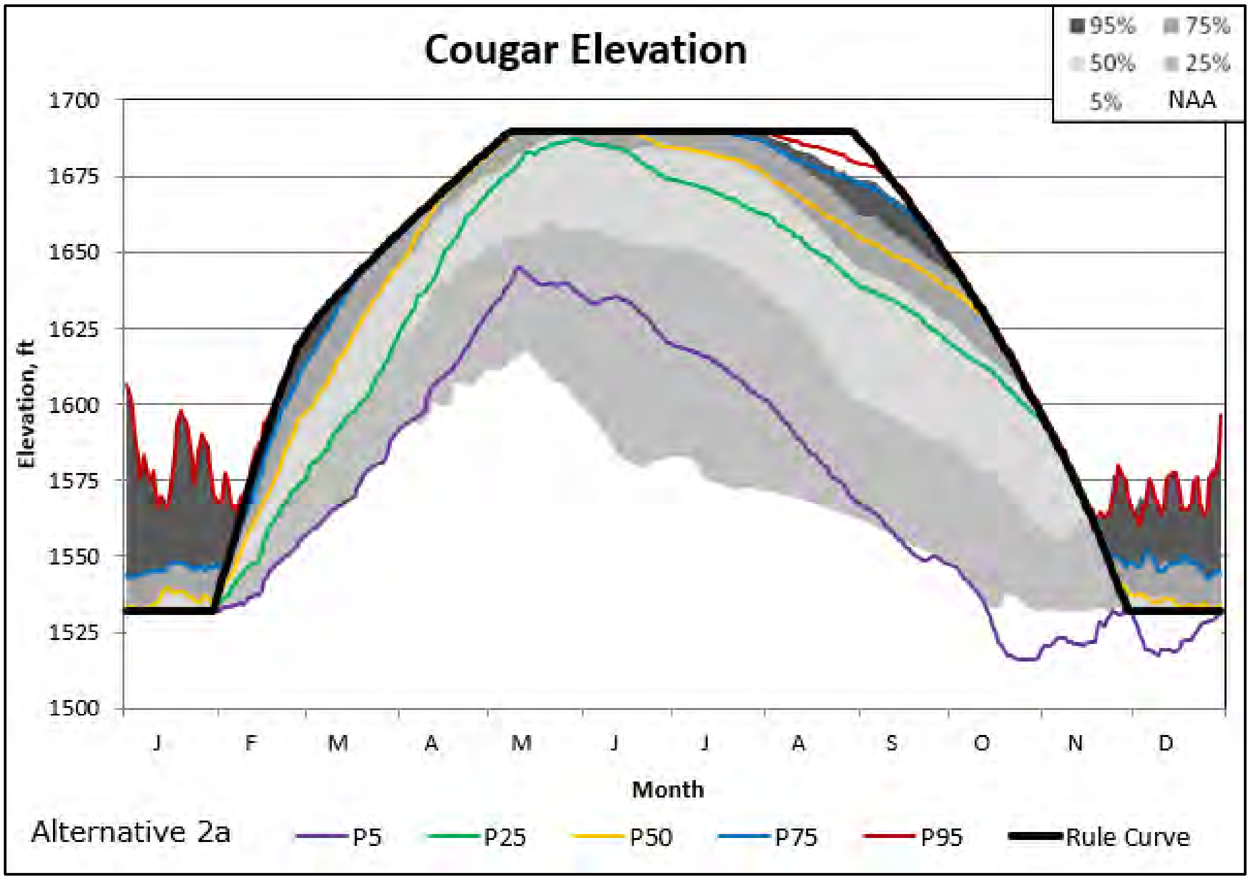



**Figure 3.2-59. Alternative 2A Cougar water surface elevation non-exceedance compared with NAA**

Blue River reservoir (Figure 3.2-60) would also fill more often as compared to the NAA and would augment instream flows by using the inactive pool only after reaching its minimum conservation storage elevation. Moving downstream to the control point for both Cougar and Blue River, the McKenzie River at Vida (Figure 3.2-61) would show the effect of the lower downstream integrated temperature and habitat flow regime targets during spring of dry years. The driest years (P05 line) would be below the NAA from March to June, but above the NAA from July to October. Summer flow would be less variable in the summer across all years and winter flow would remain the same as the NAA.

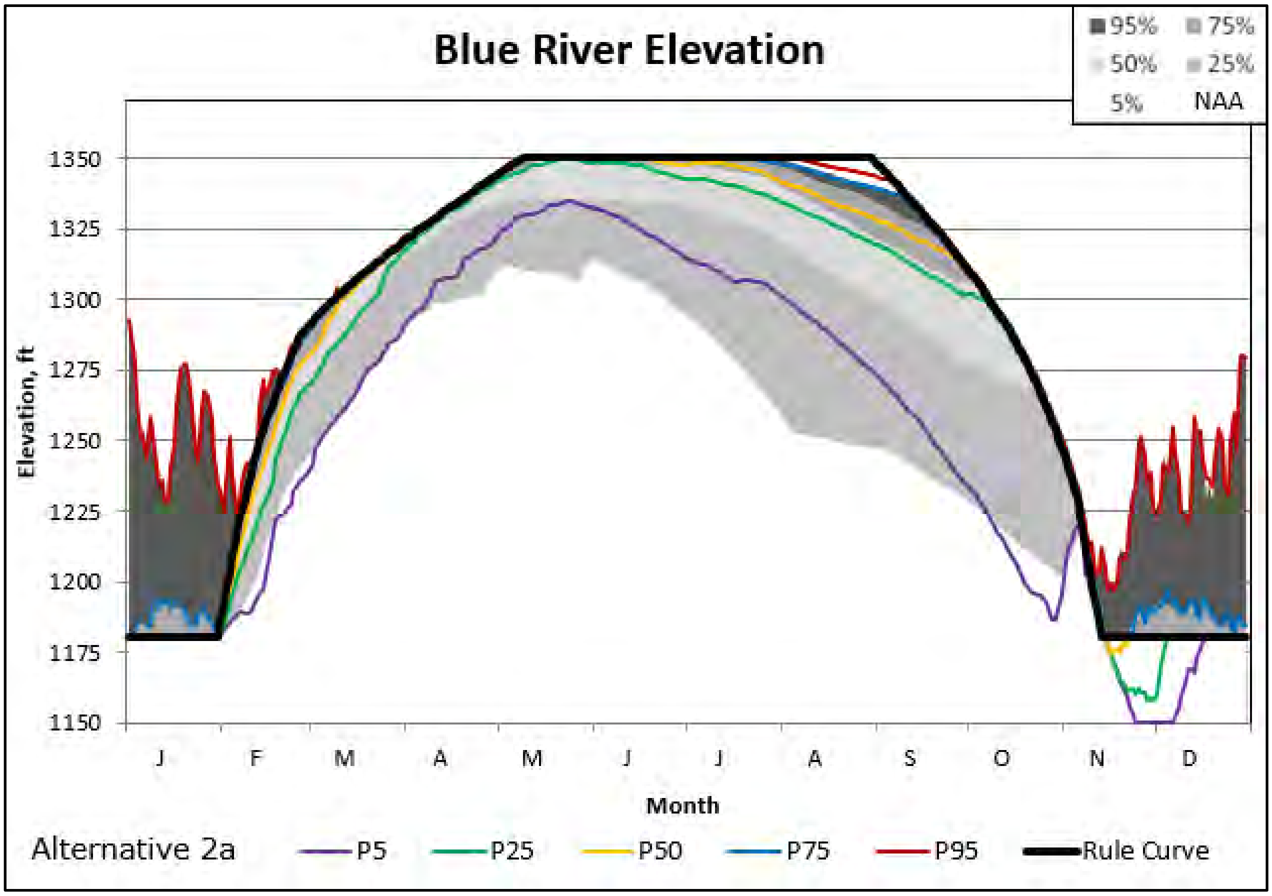



**Figure 3.2-60. Alternative 2A Blue River water surface elevation non-exceedance compared with NAA**

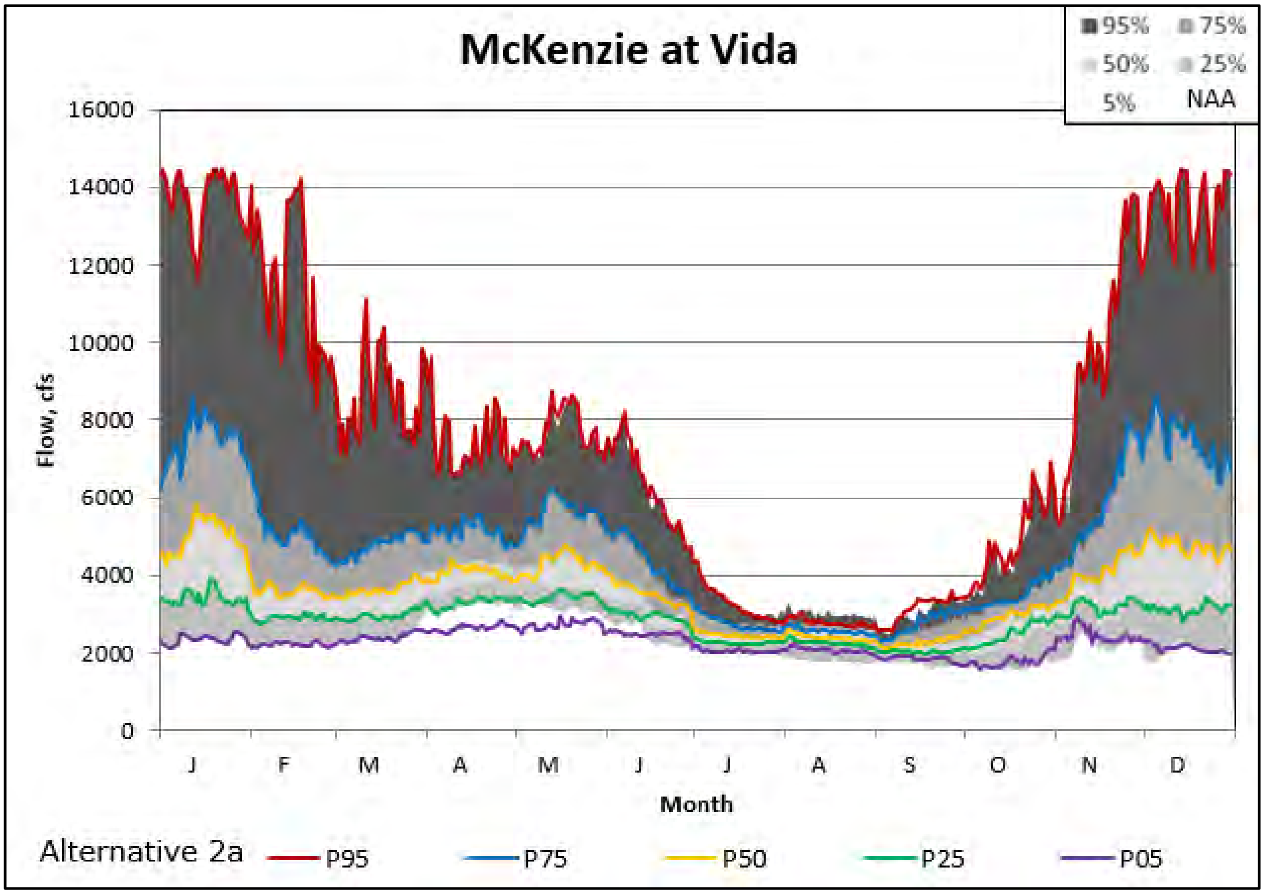



**Figure 3.2-61. Alternative 2A McKenzie River at Vida flow non-exceedance compared with NAA**

### *3.2.2.5.4 Middle Fork of the Willamette Subbasin*

Hills Creek (Figure 3.2-62) would initially fill more quickly due to the lower integrated temperature and habitat flow regime targets when the reservoir is less than 90 percent full and would stay at similar or higher elevations during wet year compared to the NAA s. During dry years, the reservoir would augment instream flows by using the power pool, releasing more water to meet the flow target at Albany. Its capacity would be exhausted in the driest years (P05 line), at which point Lookout Point would supply additional water, reaching its Alternative 2A minimum in late October in Figure 3.2-63. Alternative 2A would miss the integrated temperature and habitat flow regime target below Dexter when Lookout Point is at its minimum power pool. As compared to Alternative 2B, storage elevations for both Hills Creek and Lookout Point would be slightly higher across all years compared to the NAA. Since Cougar has much more storage in Alternative 2A, it would be able to contribute more to downstream flow targets, meaning the Middle Fork reservoirs would not have to make up for this deficit.

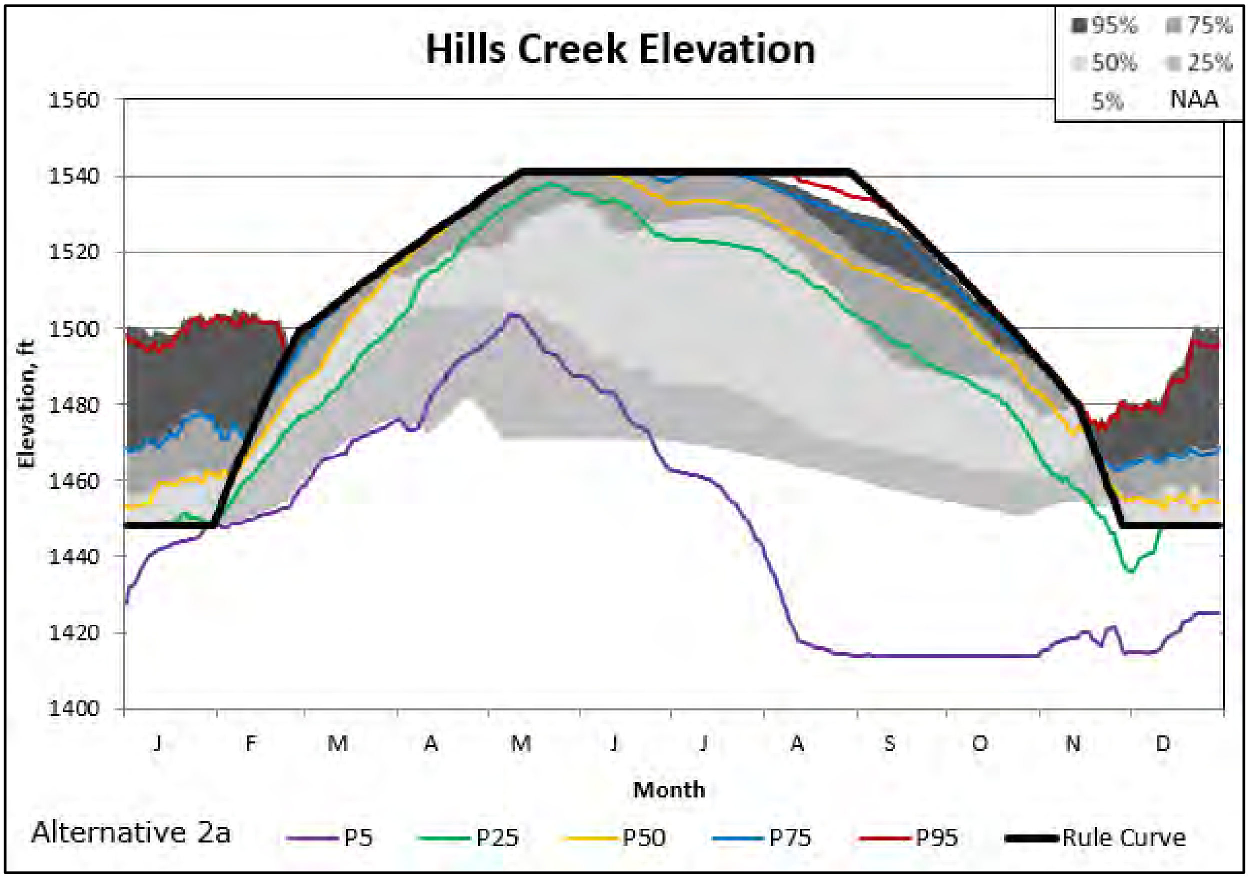



**Figure 3.2-62. Alternative 2A Hills Creek water surface elevation non-exceedance compared with NAA**

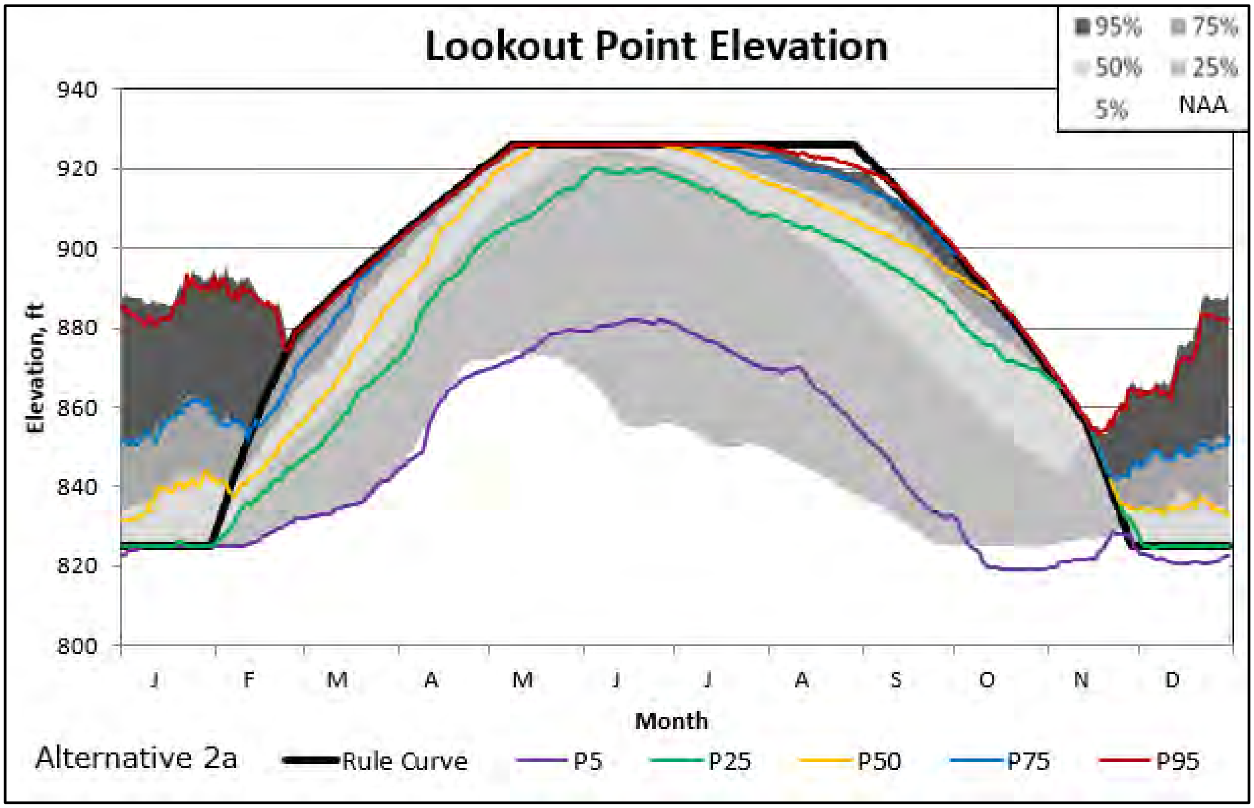



**Figure 3.2-63. Alternative 2A Lookout Point water surface elevation non-exceedance compared with NAA**

Fall Creek reservoir would show only marginal differences from the NAA in Alternative 2A (Figure 3.2-64).

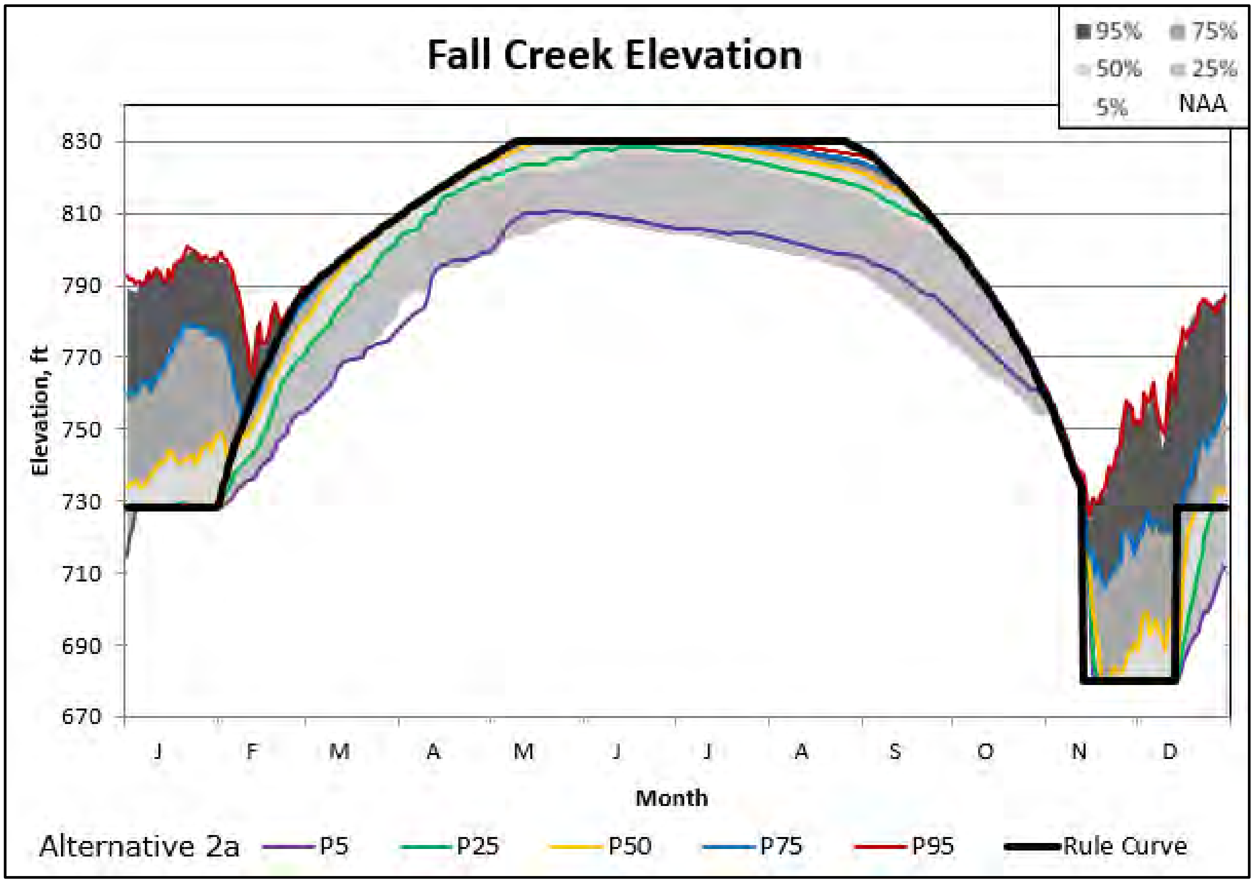



**Figure 3.2-64. Alternative 2A Fall Creek water surface elevation non-exceedance compared with NAA**

At the downstream control point at Jasper (Figure 3.2-65), the shift in release of stored water in dry years would evident, with lower flows in the spring and higher flows in the summer and fall. The increased fall flows during wet years are due to the reservoirs starting at a higher elevation prior to drafting for flood season. There would be more water to release from the reservoirs so there is higher flow downstream of them compared to the NAA.

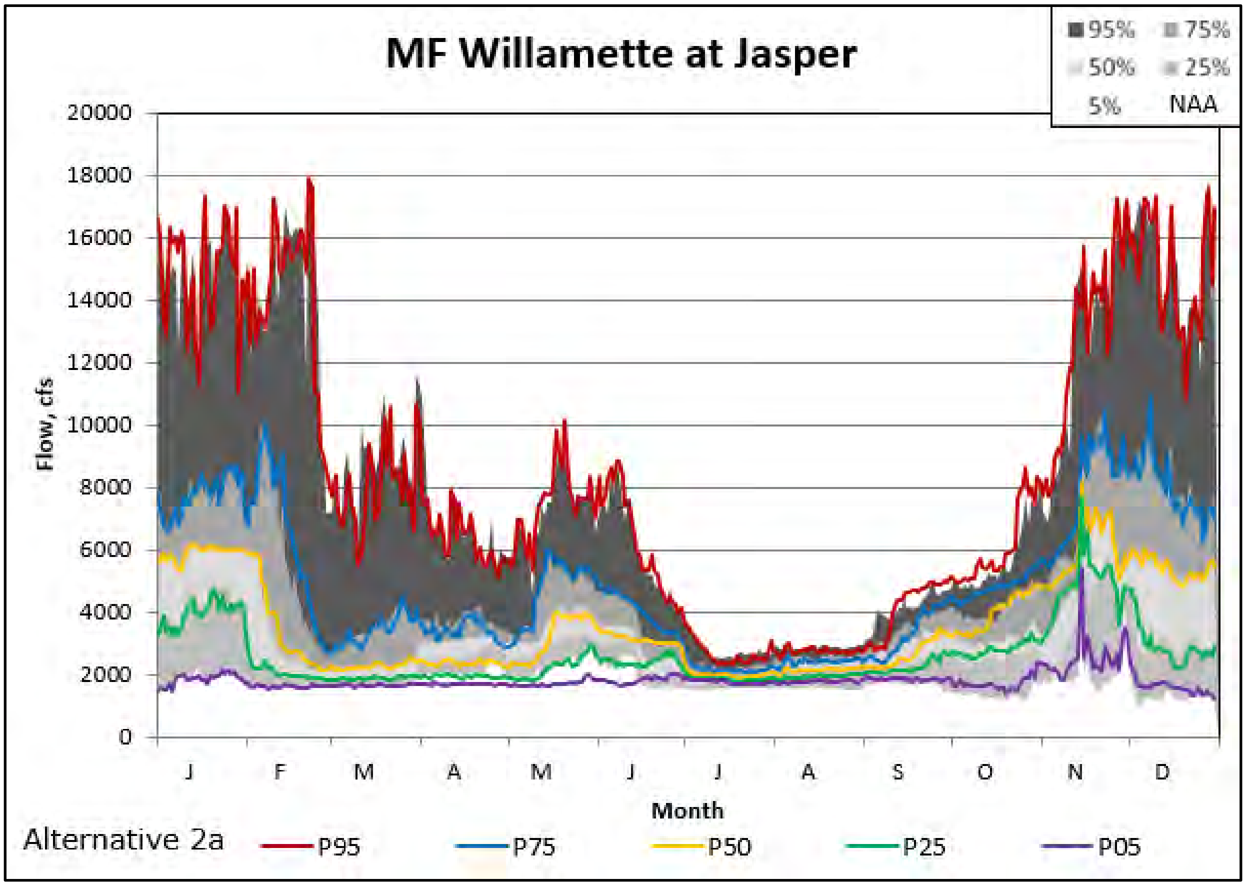



**Figure 3.2-65. Alternative 2A Middle Fork of the Willamette River at Jasper flow non-exceedance compared with NAA**

### *3.2.2.5.5 Coast Fork of the Willamette Subbasin*

For Alternative 2A, the Coast Fork subbasin would also store more water in the spring and release it during the summer and fall during dry years. It is generally similar to the NAA in wet years. Reservoir elevations would be somewhat higher at both Dorena (Figure 3.2-66) and Cottage Grove for Alternative 2A during the late spring and summer, with other times similar to the NAA. Figure 3.2-67 shows the control point at Goshen. Since the pools stay higher throughout the summer, more water would be released during September and October.

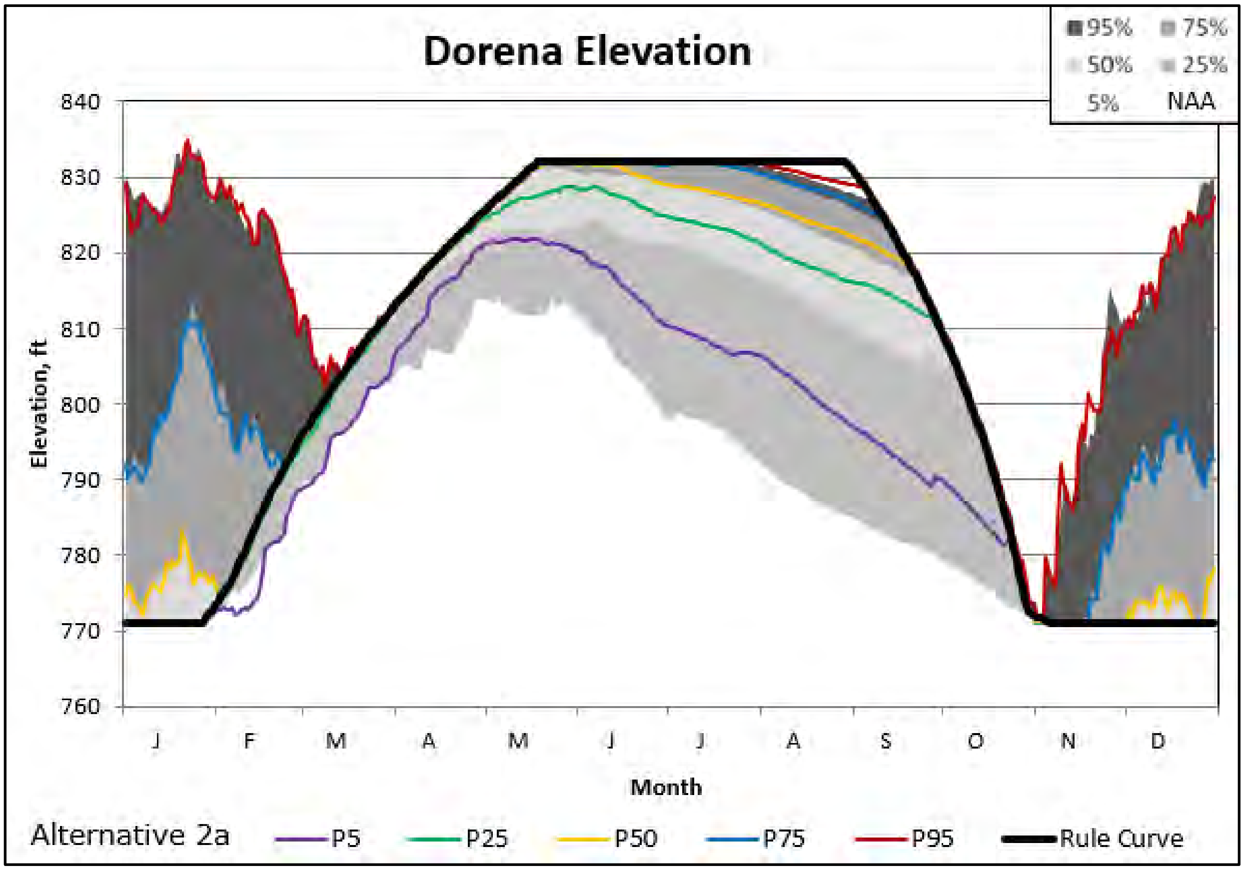



**Figure 3.2-66. Alternative 2A Dorena water surface elevation non-exceedance compared with NAA**

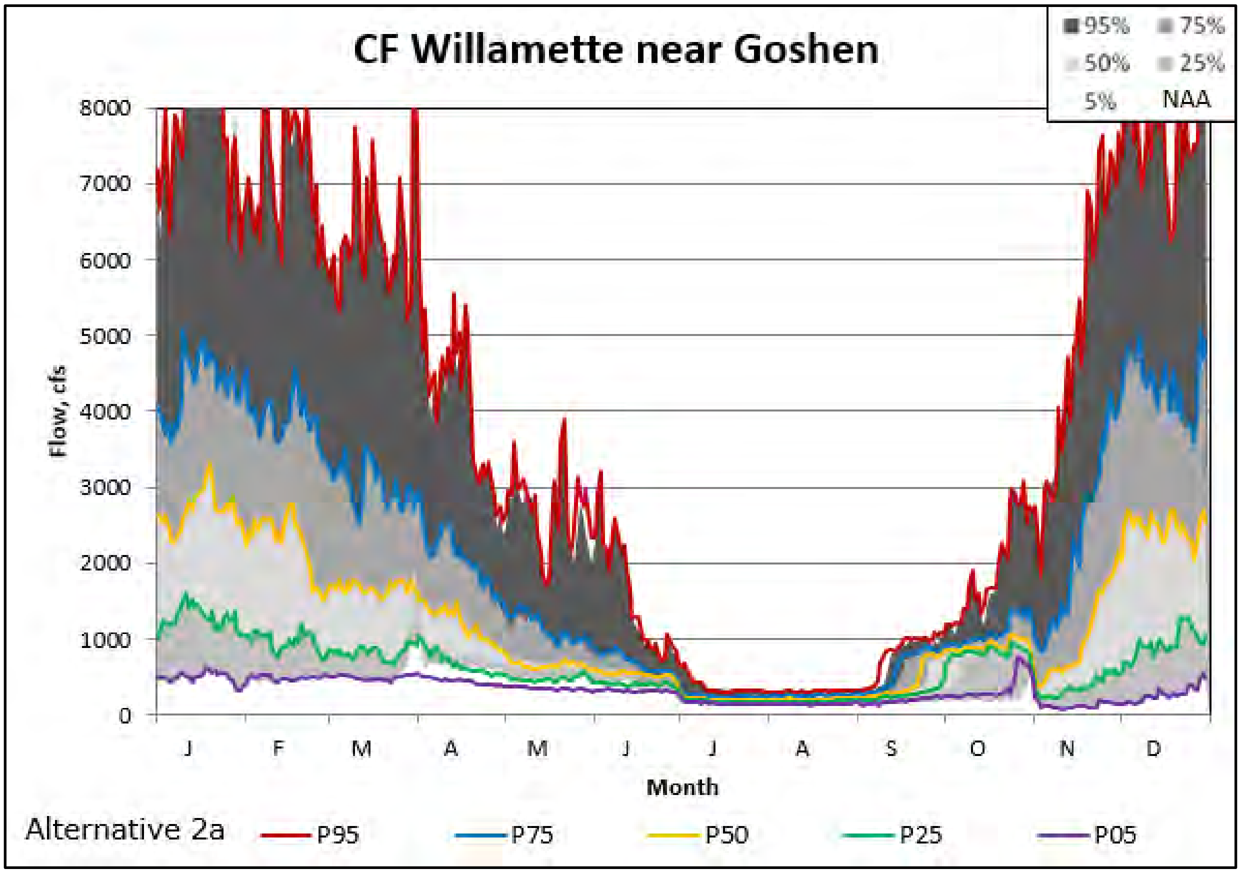



**Figure 3.2-67. Alternative 2A Coast Fork of the Willamette River at Goshen flow non-exceedance compared with NAA**

### *3.2.2.5.6 Mainstem Willamette River*

Alternative 2A would alter the regulated hydrology of the mainstem Willamette River control points, storing water more water in the spring and releasing it during the summer. The Willamette River at Albany (Figure 3.2-68) would show dry years below their NAA equivalents from April to June and a compressed flow regime through the summer, with the higher flow years reduced and the low flow years increased compared to the NAA. The WVS would nearly always meet the lower integrated temperature and habitat flow regime target at Albany, missing only a few days in the fall of the driest years. The increased flow in September and October would be due to the WVS higher reservoir levels at the start of the preparation for flood season.

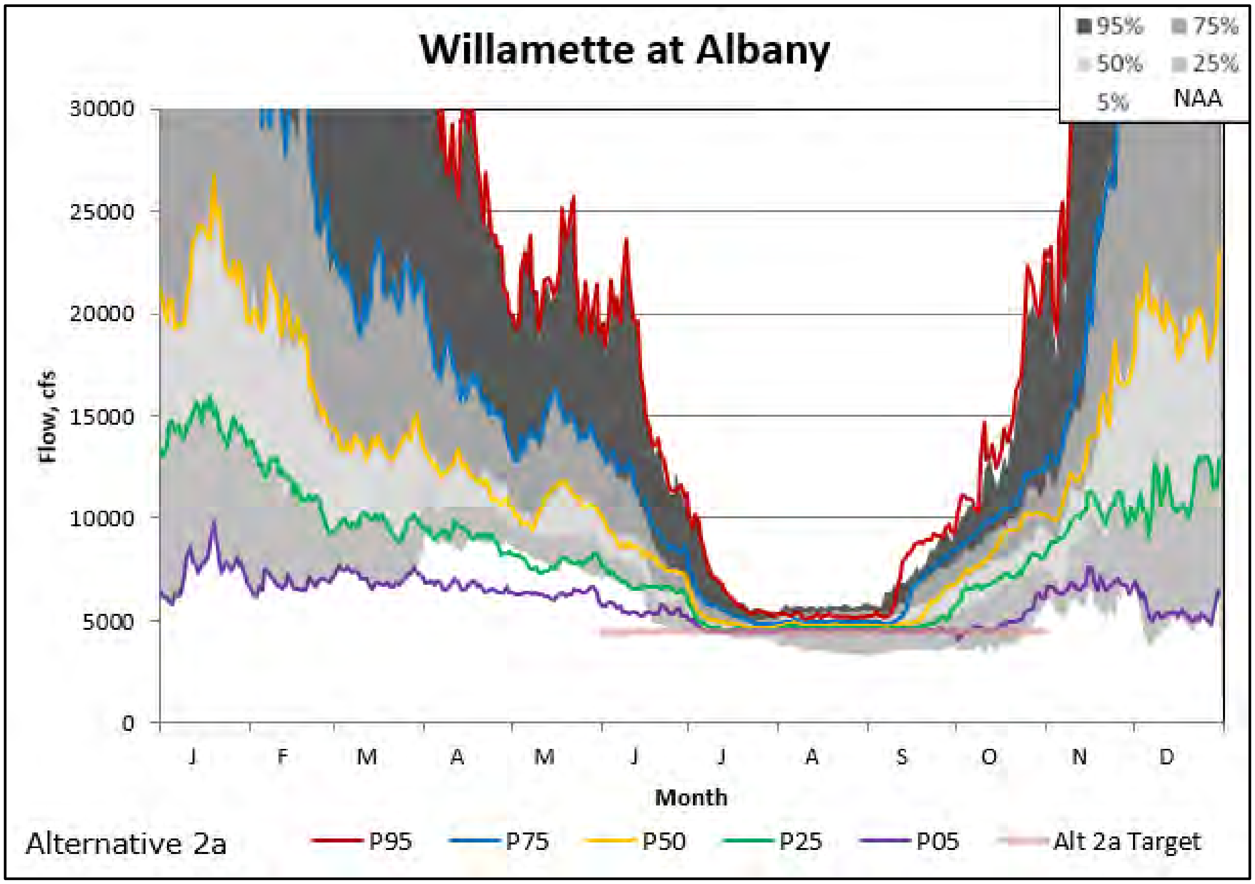



**Figure 3.2-68. Alternative 2A Willamette River at Albany flow non-exceedance compared with NAA**

Like the Albany control point, the Willamette River at Salem (Figure 3.2-69) would show reduced flows from April to June of dry years, while meeting the integrated temperature and habitat flow regime variable air-temperature-guided target compared to the NAA. Summer and fall flows would increase across all years as compared to the NAA. The increase flows from September to November would be due to the deeper fall reservoir drawdown at Green Peter. These increases are within the river channel (up to 90,000 cfs), meaning they would not impact flood risk.

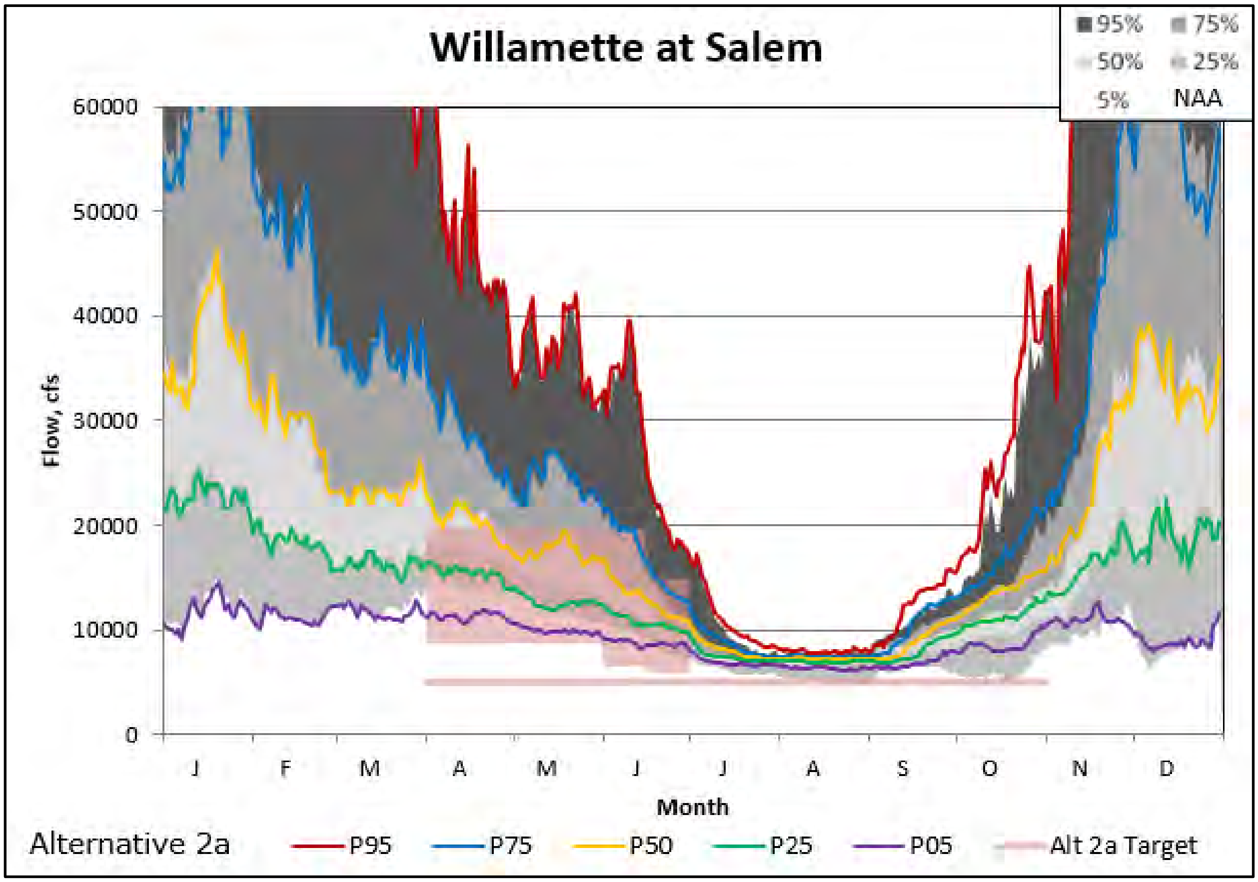



**Figure 3.2-69. Alternative 2A Willamette River at Salem flow non-exceedance compared with NAA**

*3.2.2.5.7 Near-Term Operations*

The descriptions of the Near-Term Operations can be found within Section 2.2.5, Suite of Near-term Operations Measure. The analysis of effects of the near-term operations measure on hydrologic processes is broken down into subbasins. Only the actions that affect the flow from a WVS dam are modeled. Other actions in the Near-Term Operations Measure, such as the reintroduction of salmonids in selected river reaches, do not affect flow and are not included in this section. Although there are some additional operations that affect flow (Appendix B, Hydrologic Processes Technical Information, contains a complete hydrologic operations model explanation) the most notable operations modeled in this section are:

- Change in outlet operations at Detroit based on reservoir water surface elevation
- Deeper fall reservoir drawdown at Green Peter and increase in the use of the spillway during the spring
- Delayed spring refill and earlier reduction in pool elevation at Foster
- Delayed spring refill and deeper fall reservoir drawdown at Cougar, with a downstream flow restriction during some drawdown periods.

- Change in outlet operations at Hills Creek based on reservoir water surface elevation
- Lower spring and summer maximum reservoir elevation at Lookout Point and a deeper fall reservoir drawdown. Increased use of the spillway based on reservoir water surface elevation
- Delayed spring refill from the longer fall reservoir drawdown at Fall Creek, with step increases in reservoir water surface elevation through the winter

The Near-Term Operations Measure is only contained in Alternatives 2A, 2B, 3A, 3B and 4 so the “Integrated Temperature and Habitat Flow Regime” targets were used. Briefly, this would modify flow targets at a WVS reservoir if it is at more or less than 90 percent of rule curve elevation. Flows are reduced within a range down to minimums needed for fish survival when reservoirs are under the 90 percent threshold. Section 2.2.1, Flow Measures, contains a complete explanation of the flow targets.

The Near-Term Operations Measure would reduce WVS storage in the conservation season as compared to the NAA in the Middle Fork and McKenzie subbasins. The shift in flow from spring to summer and fall that is evident in some PEIS alternatives using the integrated temperature and habitat flow regime is notably muted by this reduction in WVS storage. The delayed refill or lower maximum pool elevation require the WVS to release water in the spring that is stored in the NAA and some other alternatives, which means lower reservoir elevations and outflows throughout the summer and early fall.

On the mainstem Willamette River, Albany would show a greater impact from the lower WVS storage than Salem. This is mostly due to Detroit and Green Peter reservoirs releasing water to contribute to the Salem flow target, whereas Albany is upstream of the Willamette’s confluence with the Santiam River.

**Santiam Subbasin**

Detroit Reservoir would fill more often during conservation use season and would achieve a higher elevation when it does not fill, as shown in Figure 3.2-70. The integrated temperature and habitat flow regime target is lower than the 2008 NMFS BiOp flows during drier years. More water would be released from storage during average and wetter years, meaning the reservoir water surface elevation would meet the rule curve later in the year at levels above the P50 non-exceedance line compared to the NAA.

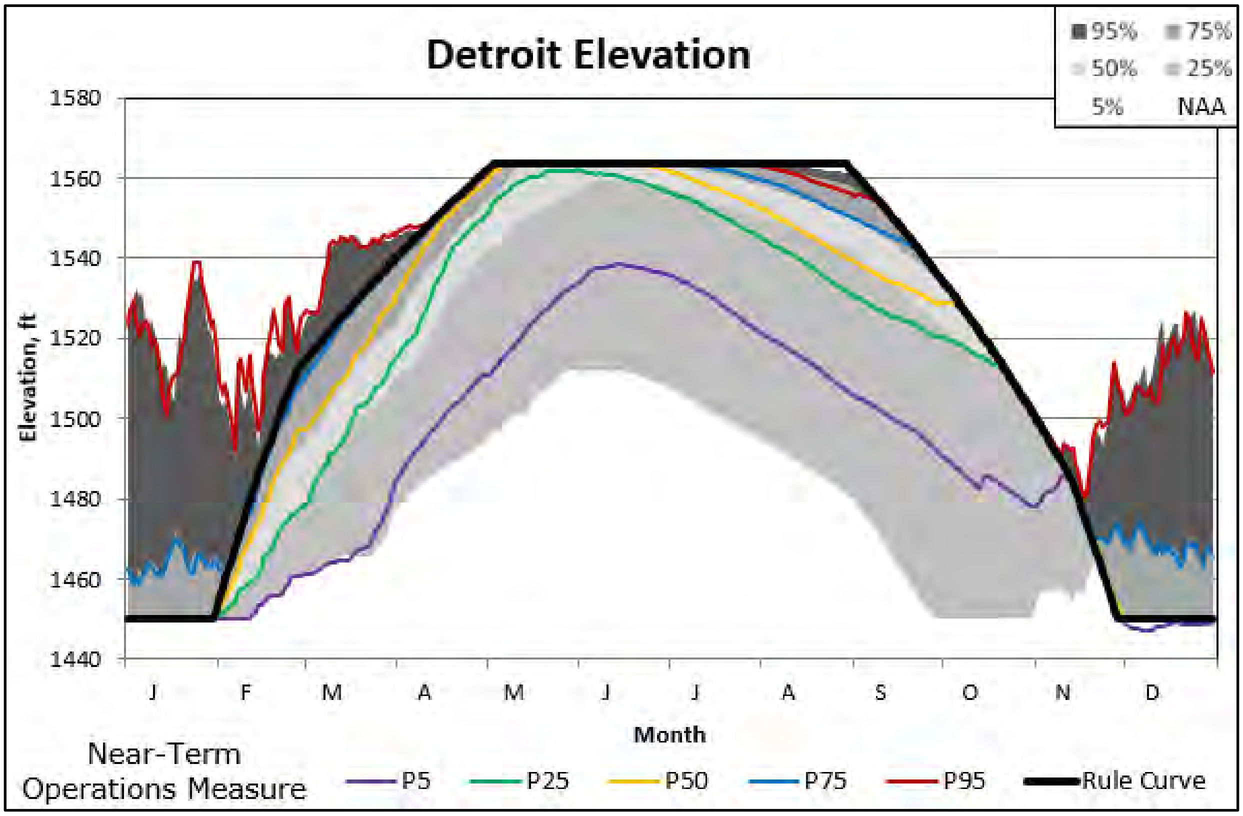



**Figure 3.2-70. Near-Term Operations Measure Detroit water surface elevation non-exceedance compared with NAA**

Green Peter reservoir (Figure 3.2-71) would fill to lower levels in the spring and elevations continue to be lower in the summer and fall as compared to the NAA. Although the lower integrated temperature and habitat flow regime flow targets downstream of Foster would still be in effect for this measure, Green Peter would also be required to use the spillway, which imposes a minimum flow of 800 cfs while in use. Over the course of several months, this would lead to lower reservoir elevations, and higher flow directly downstream, than the NAA.

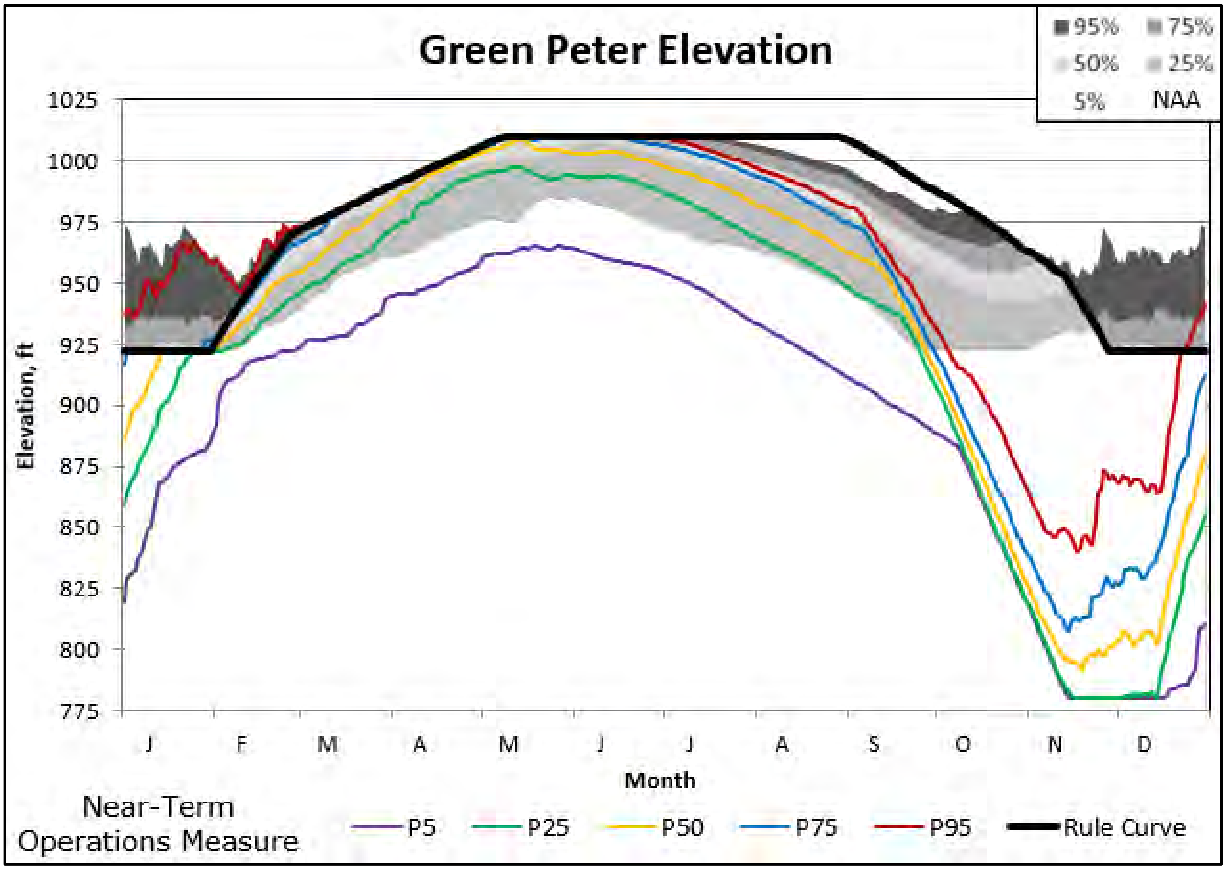



**Figure 3.2-71. Near-Term Operations Measure Green Peter water surface elevation non-exceedance compared with NAA**

The small dip in reservoir elevation at Green Peter in May is the result of Foster's delayed refill until that time, as shown in Figure 3.2-72. Since the usable storage in Foster is less than 10 percent that of Green Peter (28.3 kaf and 312.5 kaf, respectively), Green Peter would be easily able to supplement natural flows to prioritize refill at Foster in May. During drawdowns, Foster must also release the water volume originating from Green Peter. The additional flow from Green Peter during its deeper fall reservoir drawdown, combined with downstream flow restrictions, would typically delay the Foster reduction in pool elevation starting in September compared to the NAA.

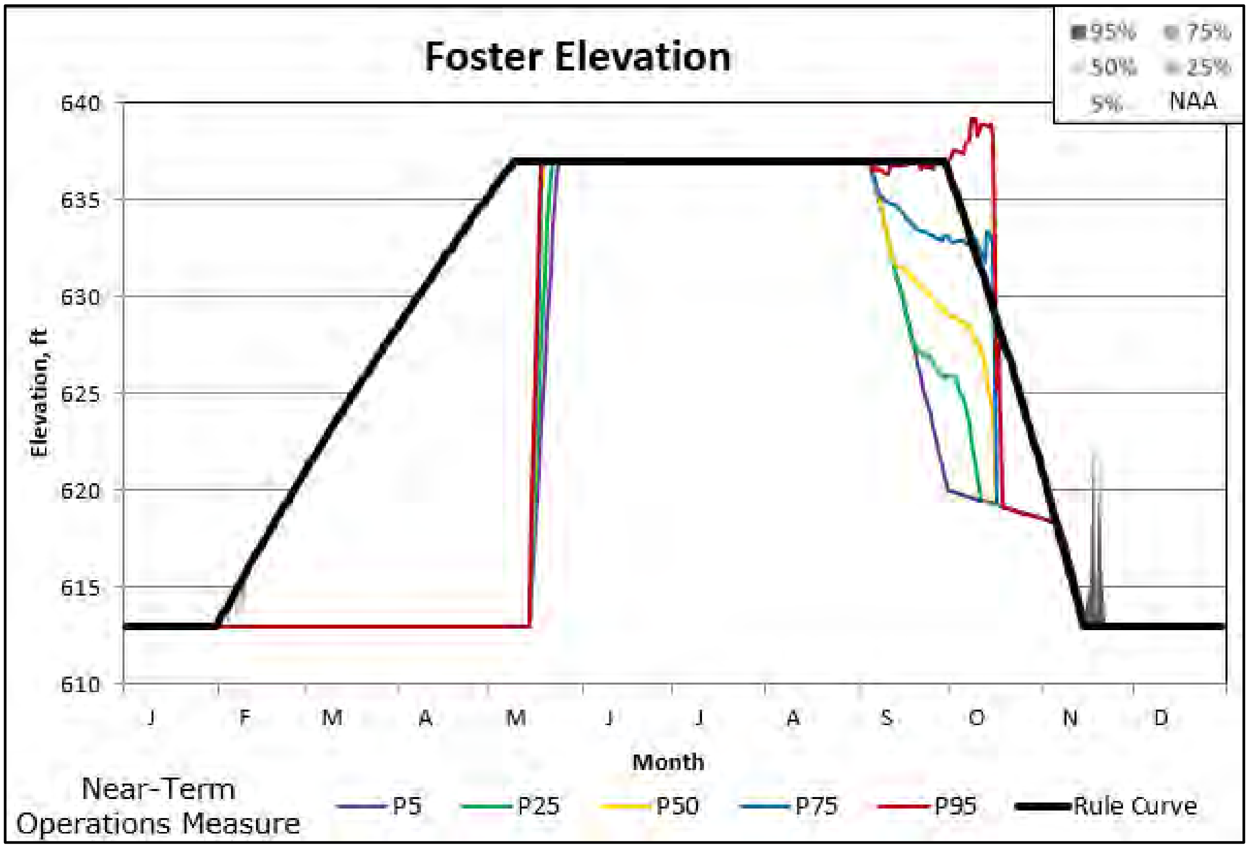



**Figure 3.2-72. Near-Term Operations Measure Foster water surface elevation non-exceedance compared with NAA**

The flow comparison out of Foster (Figure 3.2-73) shows the downstream effects of these operational changes compared to the NAA. Although the integrated temperature and habitat flow regime would remain the target flows throughout the year, it would really only dictate the flow downstream of Foster during July, August and early September. During other periods, different flow targets would be in control, such as the spillway release from Green Peter in the spring or the deeper fall reservoir drawdown in September and October. The refill of Foster is also evident in the flow downstream as it would be cut to minimum for a while in May. The actual operation would probably take place over a longer period than the modeled operation to balance refill with a higher downstream flow.

The lower November flows in the driest years would be a result of Green Peter already being at the minimum drawdown elevation, when it still had some water stored in the NAA.

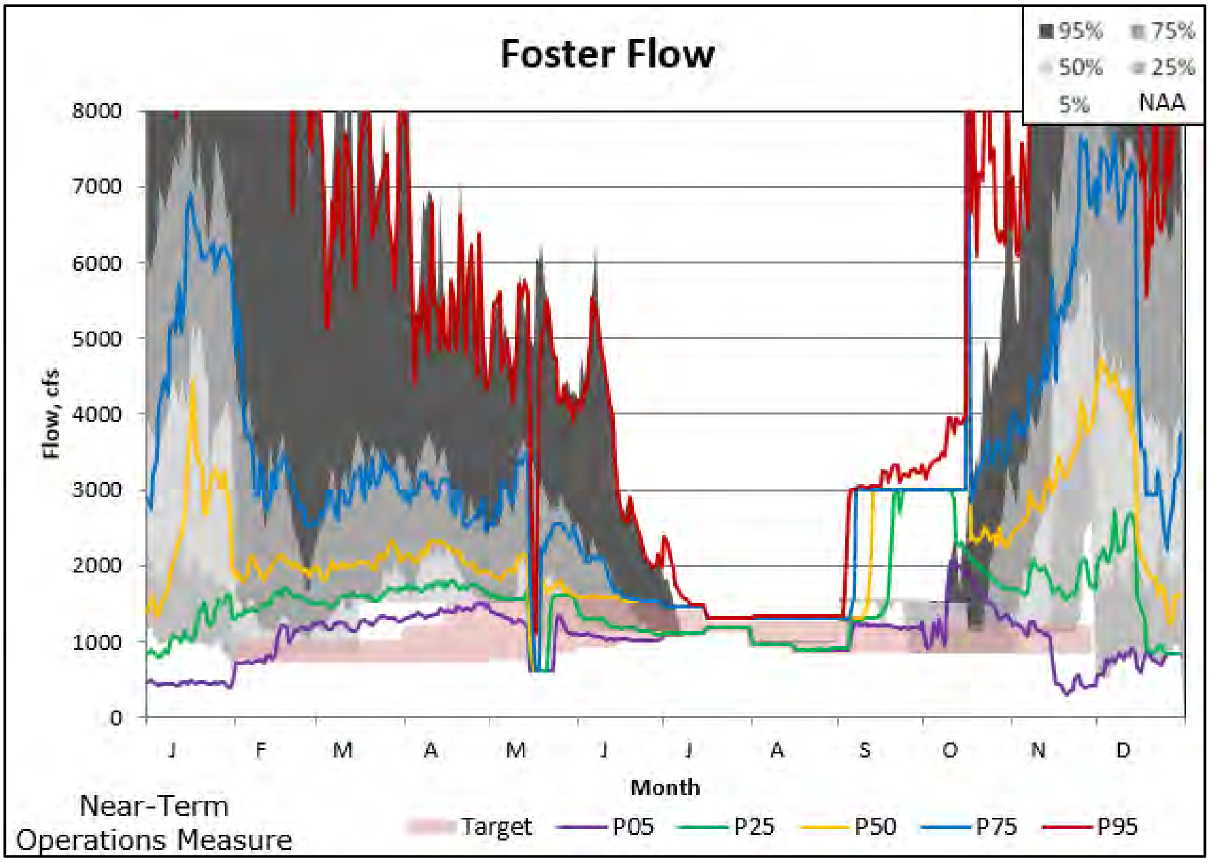



**Figure 3.2-73. Near-Term Operations Measure Foster outflow non-exceedance compared with NAA**

Although there are not specific flow targets further downstream at the combined Santiam control point at Jefferson (Figure 3.2-74), the revised operations and flow targets from upstream would be evident. The water stored during dry years, principally in Detroit, from March to June, would be released during the summer. Upstream summer integrated temperature and habitat flow regime targets would be higher than those in the 2008 NMFS BiOp, so Jefferson would show higher flows in all years compared to the NAA. There would be a small reduction in flow during the refill period at Foster – during May – though not nearly as pronounced as it is directly downstream of the dam. The elevated flows during September would be due to the deeper fall reservoir drawdowns. The lower November dry-year flows in the South Santiam would all but disappear as compared to the NAA due to the contributions from Detroit reservoir.

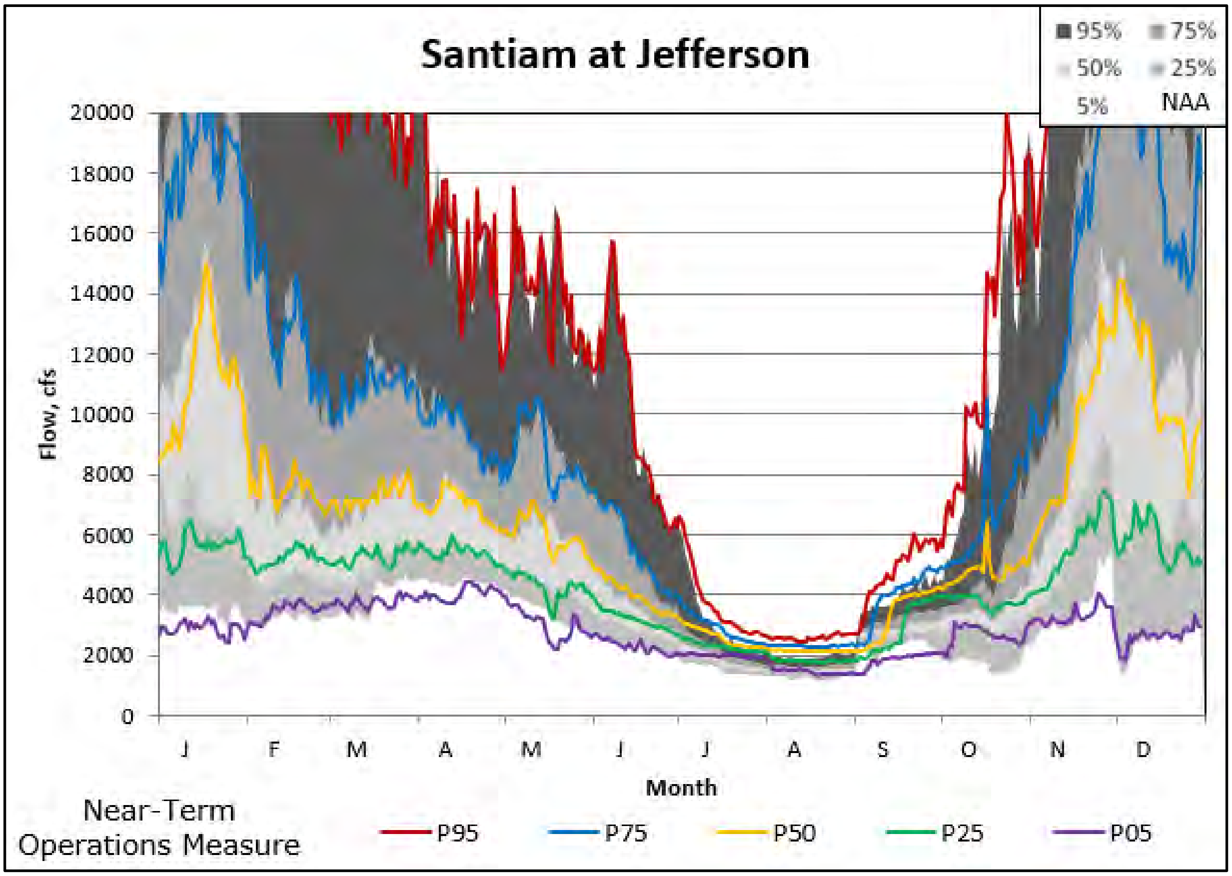



**Figure 3.2-74. Near-Term Operations Measure Santiam River at Jefferson flow non-exceedance compared with NAA**

## Long Tom Subbasin

As explained in the NAA, Fern Ridge reservoir is operated for recreation and fish and wildlife habitat in the conservation season and typically seeks to maximize the reservoir pool during the summer. The Near-Term Operations Measure does not appreciably change this goal and the hydrologic patterns are nearly the same as the NAA, as shown in Figure 3.2-75. The Near-Term Operations Measure downstream control point flows at Monroe show a similar lack of change from the NAA.

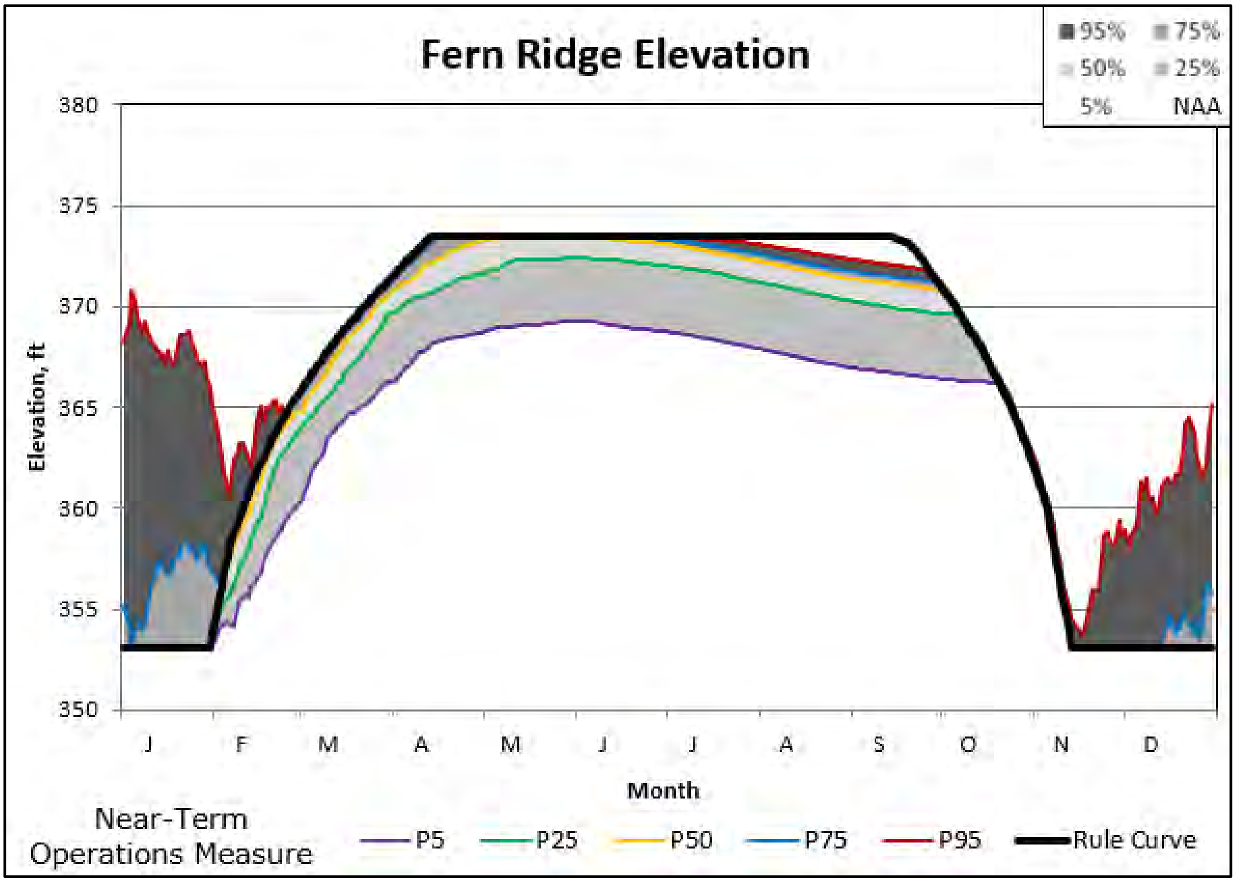



**Figure 3.2-75. Near-Term Operations Measure Fern Ridge water surface elevation non-exceedance compared with NAA**

**McKenzie Subbasin**

Blue River (Figure 3.2-76) reservoir would fill to higher elevations in dry years due to the lower spring flow targets in the McKenzie River and Salem. Since the reservoir would fill in wetter years, there is limited difference in everything above the P25 line for the conservation season. The Near-Term Operations measure would allow Blue River to augment instream flows by using the inactive pool. This would draft the reservoir below minimum conservation elevation and it would do so during very dry Novembers.

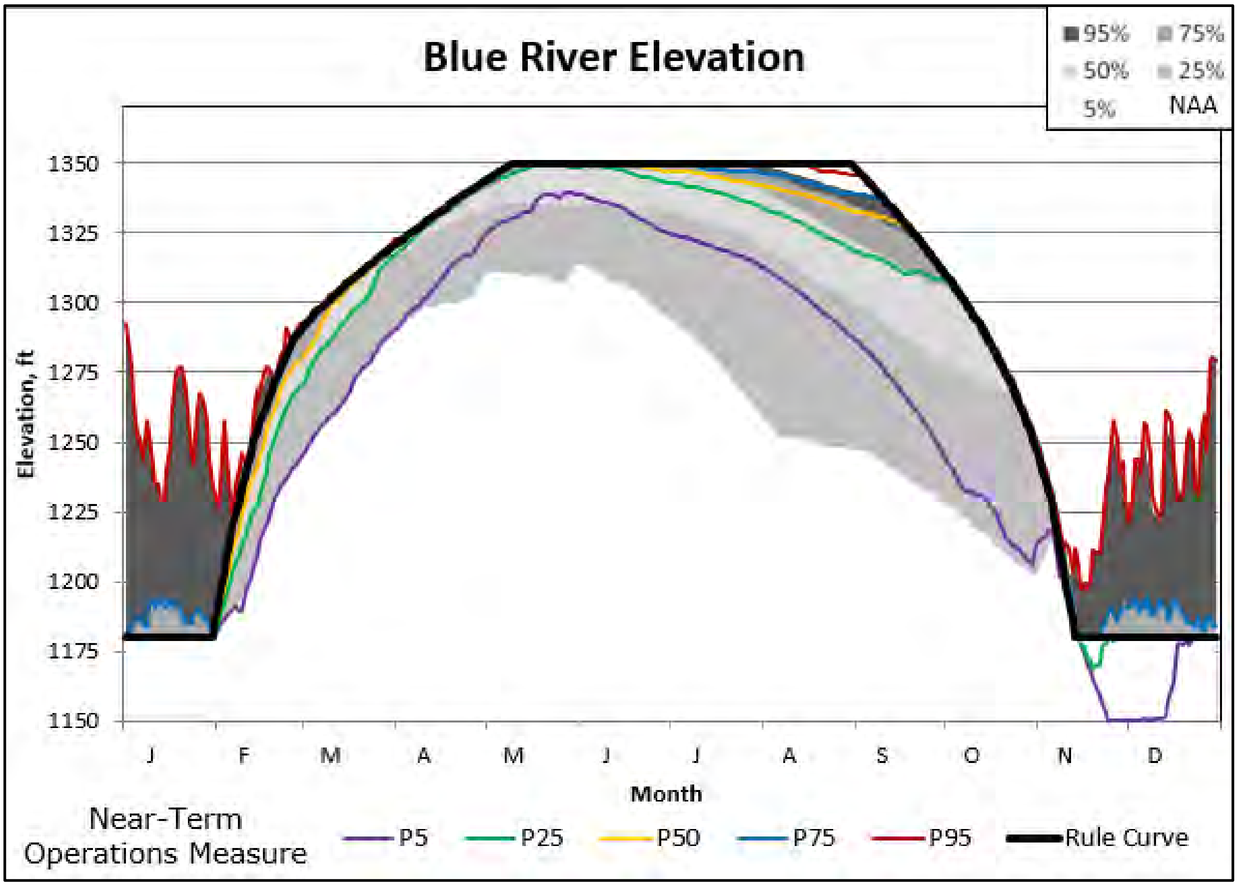



**Figure 3.2-76. Near-Term Operations Measure Blue River water surface elevation non-exceedance compared with NAA**

Cougar reservoir (Figure 3.2-77) would have a drawdown target below minimum conservation elevation (1532 ft) during the spring (1505 ft) and fall (1520 ft). The operation would also limit releases to less than about 900 cfs for water quality concerns, which is less than typical inflow during the spring and late fall compared to the NAA. This would result in the reservoir only meeting the drawdown target elevations in dry years and only for relatively brief periods.

If the operation were to prioritize the maintenance of the drawdowns over the maximum downstream flow, Cougar would not fill nearly as often as presented in Figure 3.2-77. Alternative 3A provides a similar operation of Cougar reservoir, though that spring reservoir drawdown ends in June instead of May. While ending in May would generally mean somewhat higher average inflows to Cougar at the end of the spring reservoir drawdown, it is still be expected that the reservoir would be near minimum conservation elevation for most of the summer months compared to the NAA. While the reservoir would be at minimum elevation, outflow from Cougar reservoir would be equal to inflow, which is typically lower than flow target minimums directly downstream of the dam.

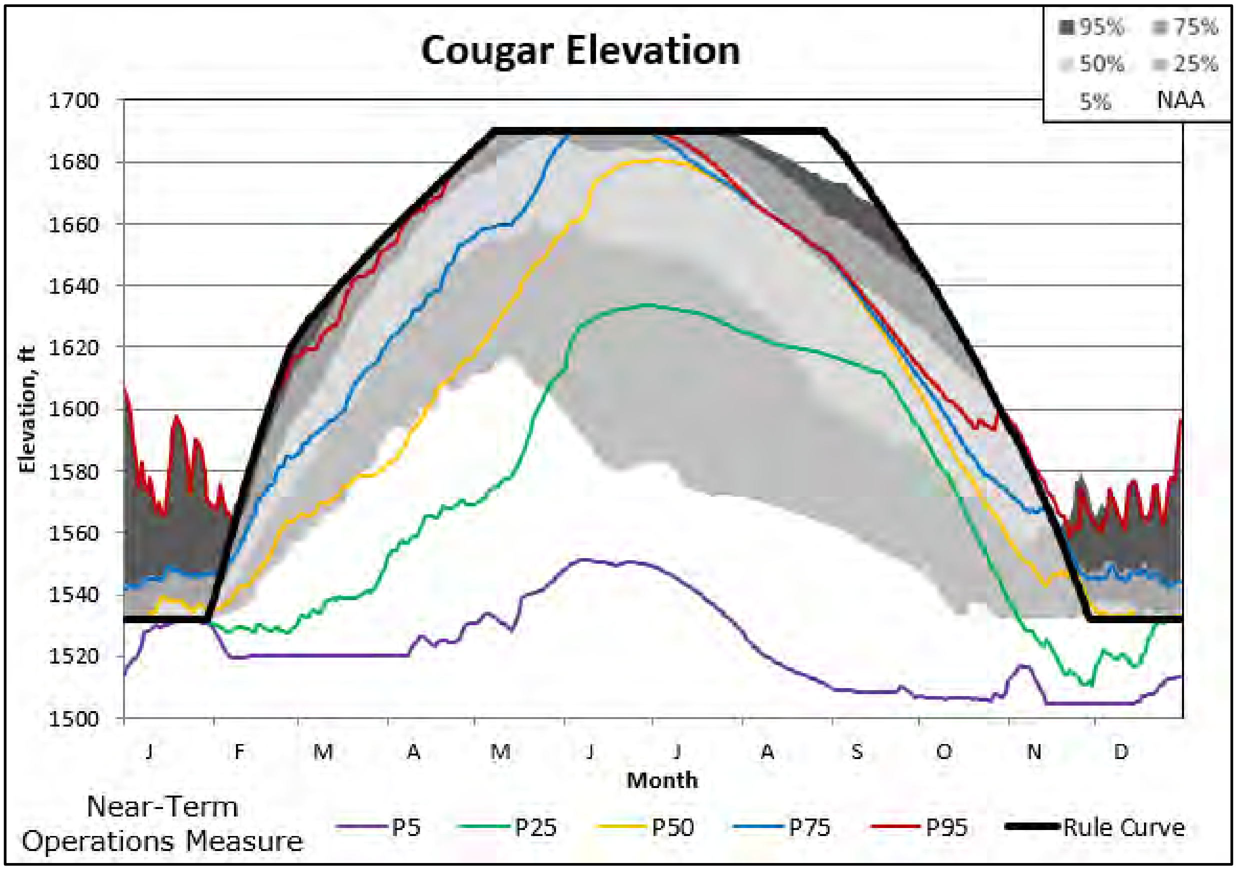



**Figure 3.2-77. Near-Term Operations Measure Cougar water surface elevation non-exceedance compared with NAA**

Cougar outflow would meet or exceeds its integrated temperature and habitat flow regime target except during the driest falls compared to the NAA, when Cougar would be at its minimum elevation and only passing inflow, as shown in Figure 3.2-78. However, those flow targets would seldom determine the actual flow in the complete set of Near-Term Operations. The drawdown flow operation of about 900 cfs determines the flow for much of the spring and fall, and maximum pool elevations dictate releases for average and wetter years throughout most of the summer.

If the maximum flow during the drawdowns were raised and the drawdown elevations maintained more frequently, the flow downstream of Cougar would only be equal to the inflow for most of the summer and fall. After May 15th there would be limited inflow to accumulate storage and the flow targets directly downstream of the reservoir would only be met in the wettest years.

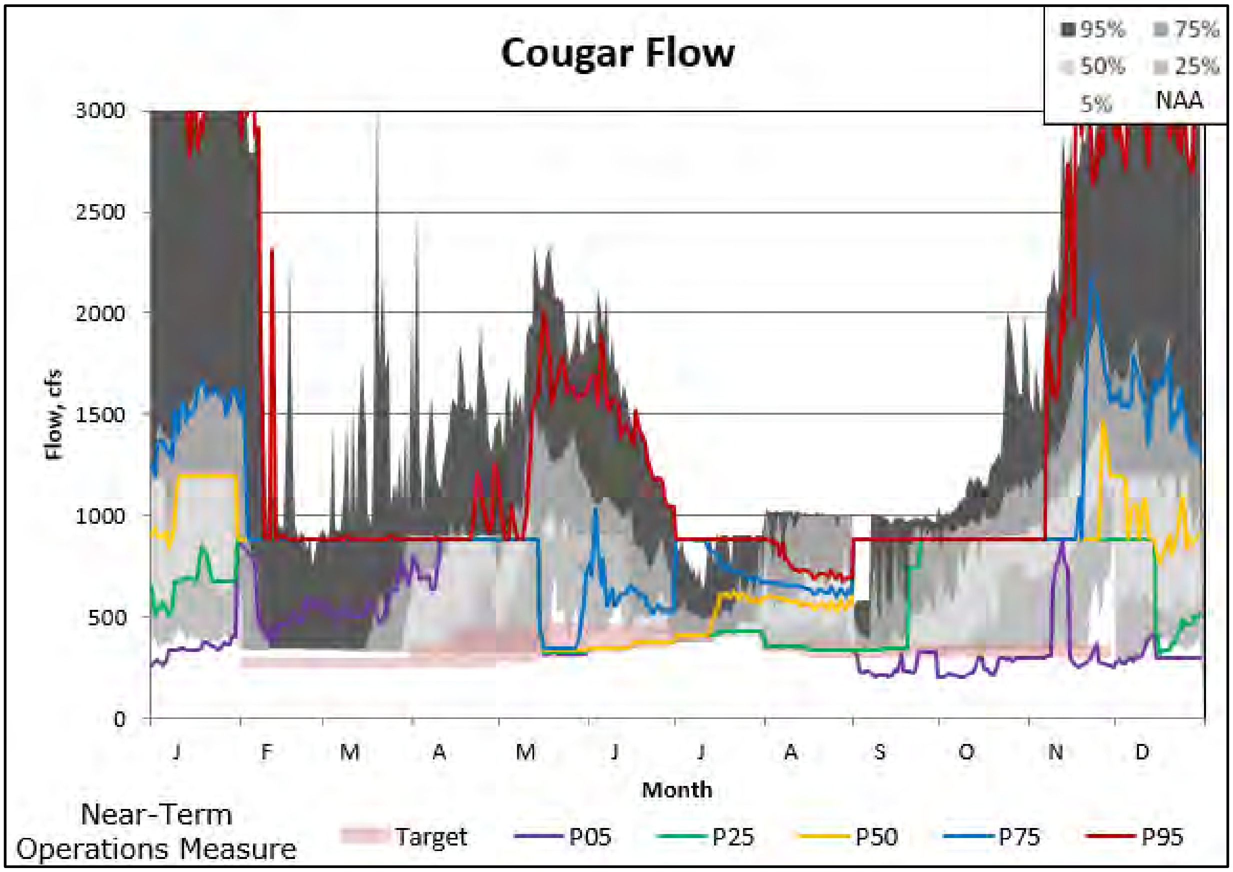



**Figure 3.2-78. Near-Term Operations Measure Cougar outflow non-exceedance compared with NAA**

Figure 3.2-79 (McKenzie River at Vida) shows the effects of lower elevations at Cougar at higher elevations at Blue River. While there are differences in timing and precise flow rates, the overall results are similar at Vida when compared to the NAA. The relatively high summer base flow in the McKenzie River also contributes to the consistency with the NAA.

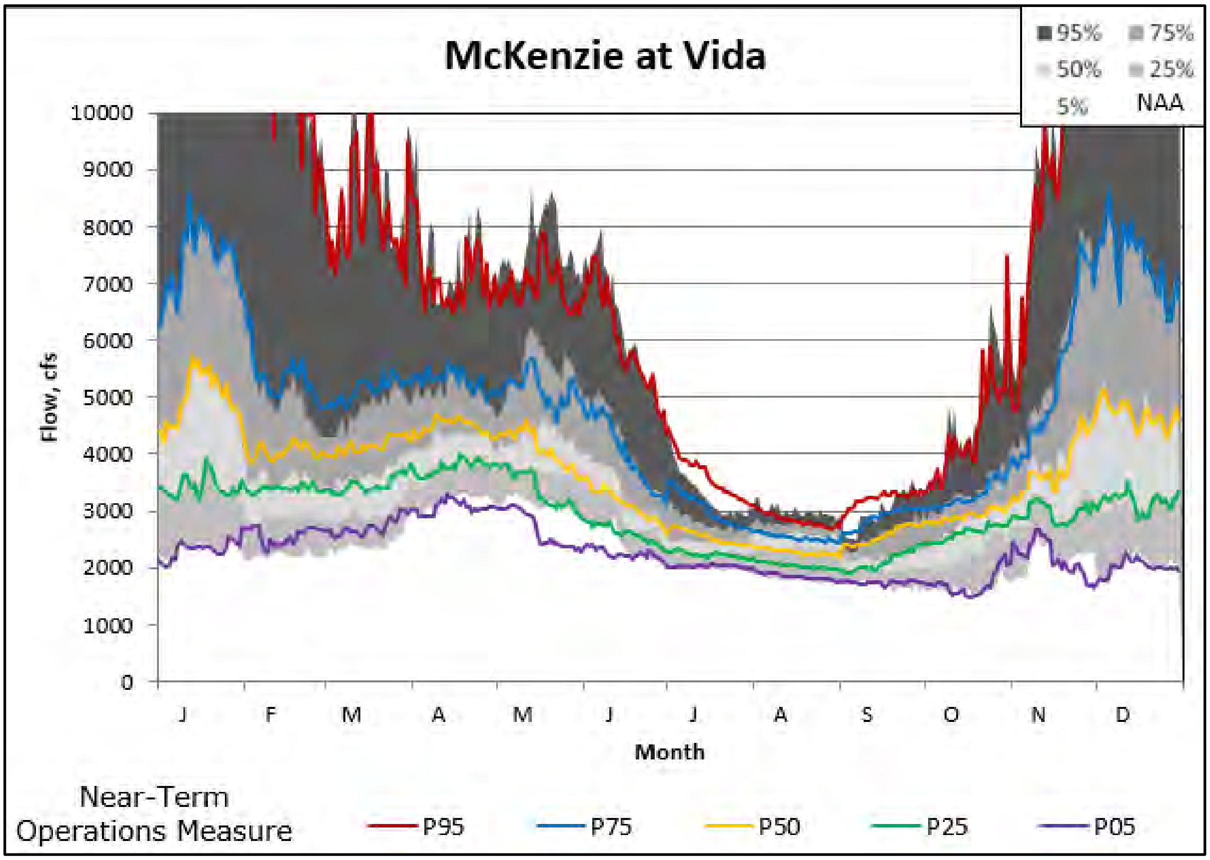



**Figure 3.2-79. Near-Term Operations Measure McKenzie River at Vida flow non-exceedance compared with NAA**

__Middle Fork of the Willamette Subbasin__

Hills Creek (Figure 3.2-80) initially would fill more slowly than the NAA due to the Near-Term Operations Measure's mandate to prioritize refill at Lookout Point (Figure 3.2-81). In other words, early in the year, water that was stored at Hills Creek in the NAA would be released to Lookout Point instead. After Lookout Point reaches its lower maximum elevation (893 feet instead of maximum conservation pool of 926 feet), Hills Creek would fill to higher elevations than the NAA due to the lower integrated temperature and habitat flow regime targets downstream.

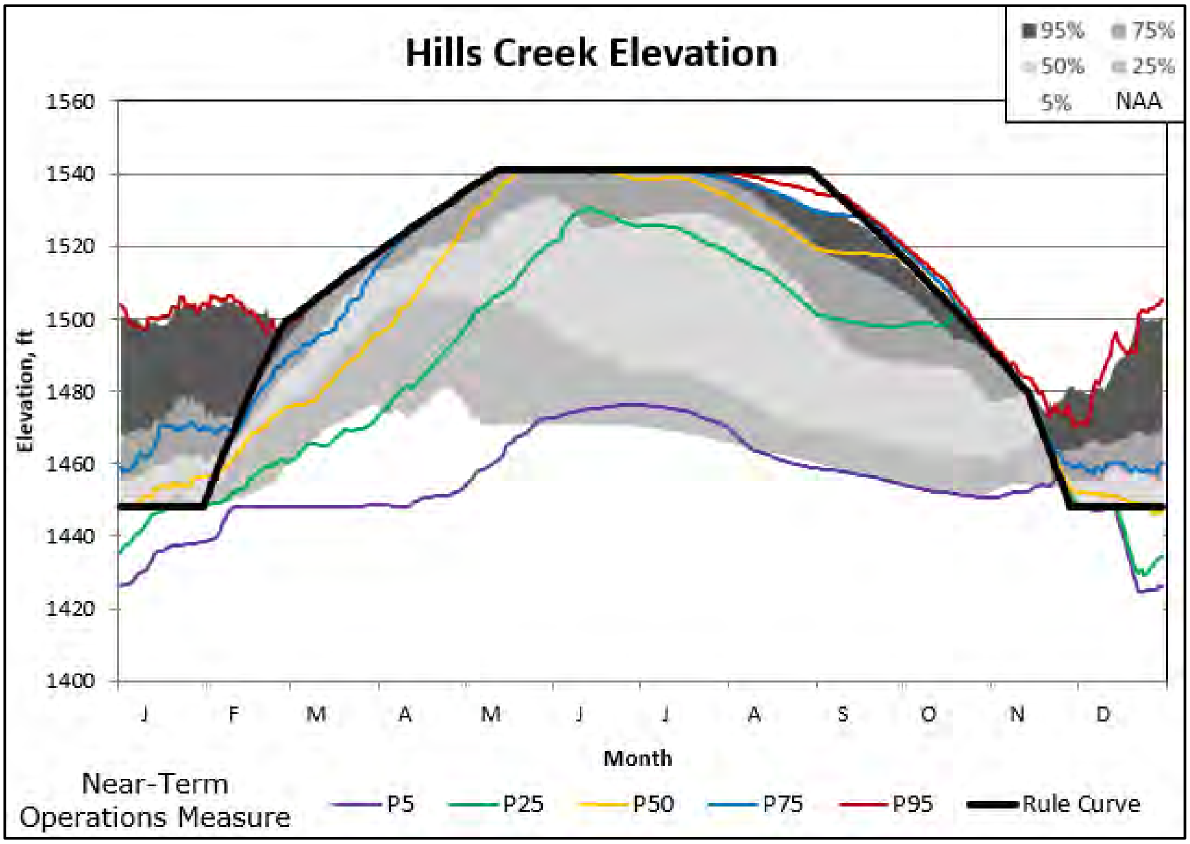



**Figure 3.2-80. Near-Term Operations Measure Hills Creek water surface elevation non-exceedance compared with NAA**

Lookout Point reservoir would fill more often to its lower target elevation than it does to maximum conservation pool in the NAA. The is due to supplementary releases from Hills Creek and because there is more volume for each foot of elevation higher in the reservoir. The deeper fall reservoir drawdown target would be achieved nearly every year, with unusually wet Novembers preventing the reservoir from making the 761-foot target. This is due to high seasonal inflow and the lower outlets would not able to release water fast enough with the pool elevation at low levels.

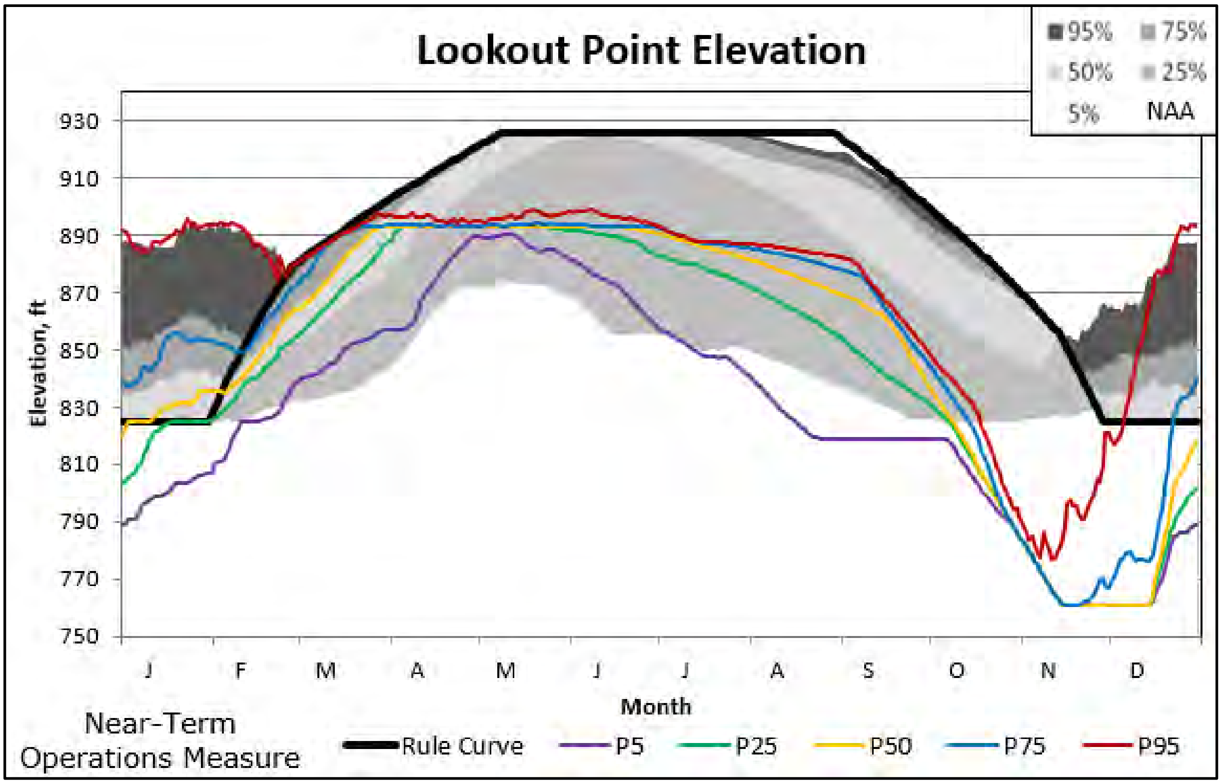



**Figure 3.2-81. Near-Term Operations Measure Lookout Point water surface elevation non-exceedance compared with NAA**

The Near-Term Operations Measure extends the lower target elevation at Fall Creek reservoir through May, increasing in steps from the deeper fall reservoir drawdown elevation already implemented in the NAA, as shown in Figure 3.2-82. The target is 700 feet after the deeper fall reservoir drawdown through March 15th and 728 feet to May 15th, after which the reservoir refills as inflow and other operations allow. Reservoir elevations are lower throughout the conservation season at Fall Creek and the releases would be below the downstream target in the fall of drier years (Figure 3.2-83). The reservoir would only pass inflow when it reaches its minimum water surface elevation, and these inflows are much less than the downstream targets. The elevated wet-year flows in the spring would be due to the reservoir releasing water to hold the target elevation rather than storing water, as it did in the NAA. These higher flows would be within the bankfull maximum.

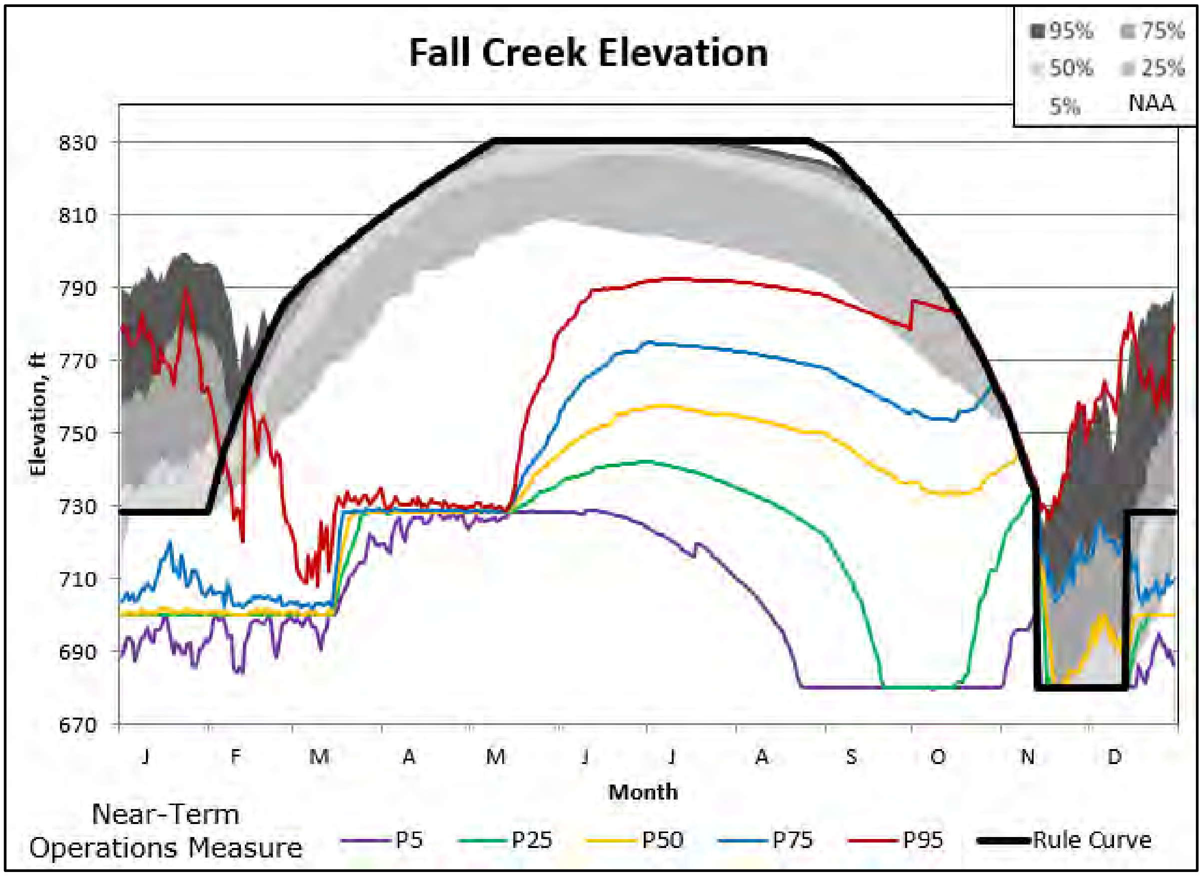



**Figure 3.2-82. Near-Term Operations Measure Fall Creek water surface elevation non-exceedance compared with NAA**

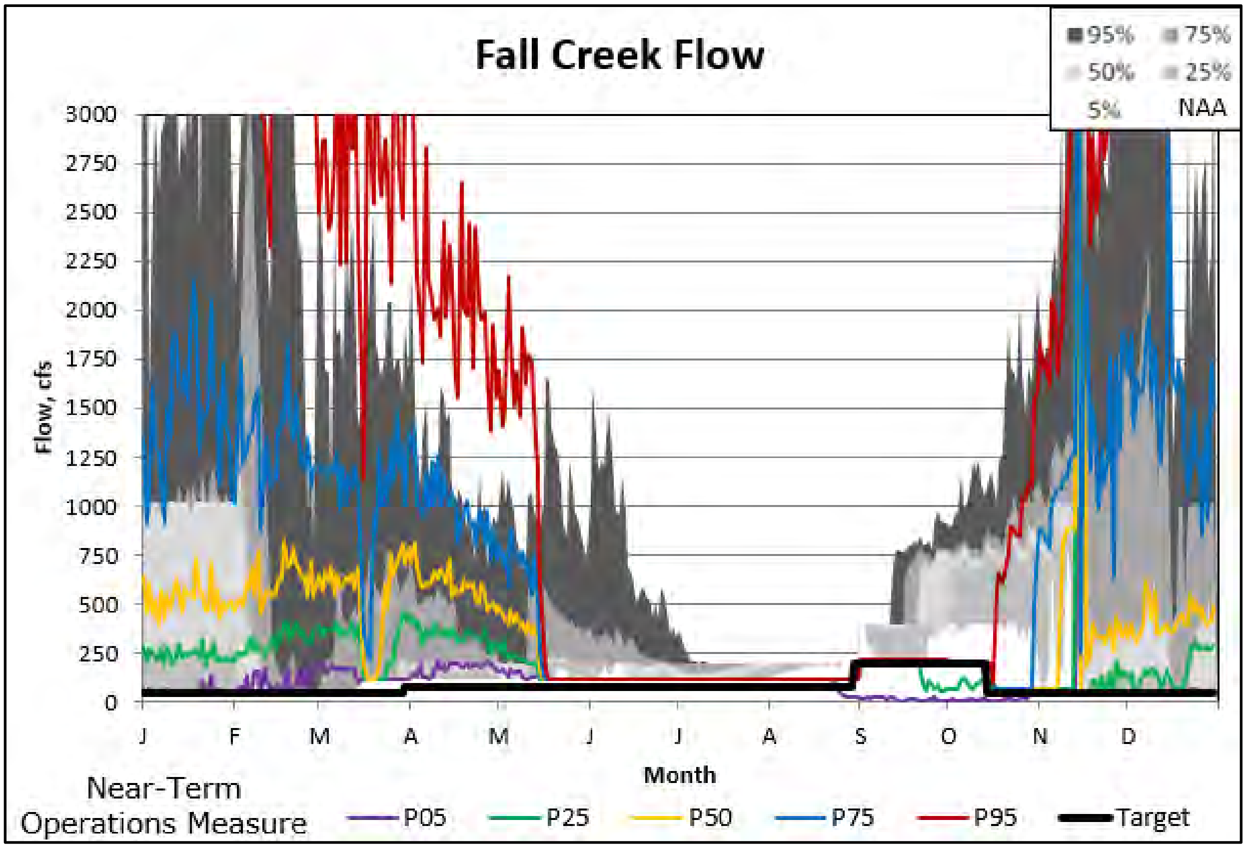



**Figure 3.2-83. Near-Term Operations Measure Fall Creek outflow non-exceedance compared with NAA**

At the Middle Fork of the Willamette River at Jasper (Figure 3.2-84), the control point for Hills Creek, Lookout Point and Fall Creek, elevated spring flows would be evident in all except the driest years. Water that would have been stored in the NAA would be released from Lookout Point and Fall Creek due to their lower target water surface elevations. Into summer and fall, a lower amount of stored water would lead to somewhat lower flows across all years. The driest Septembers would show notably lower flows compared to the NAA as all three upstream storage reservoirs would be at or near their minimum water surface elevation for that period and only able to release inflow.

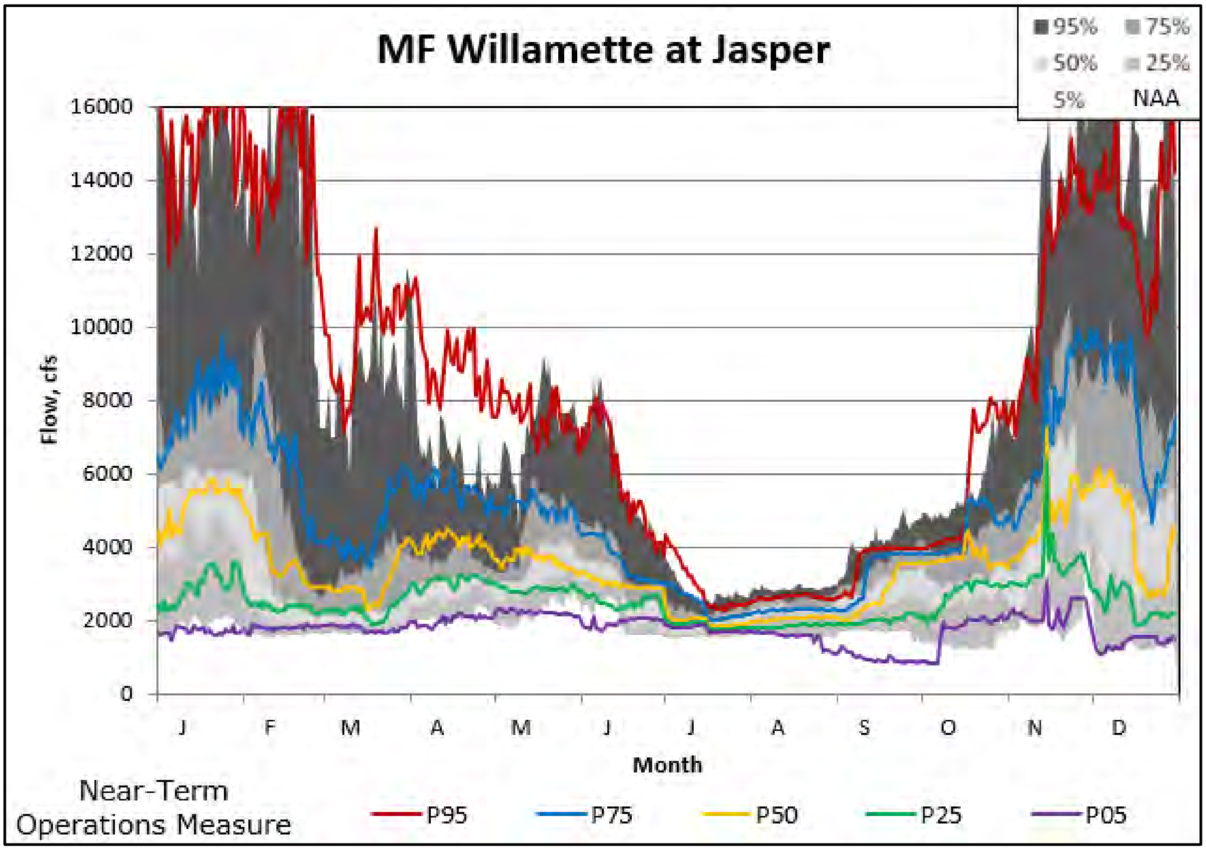



**Figure 3.2-84. Near-Term Operations Measure Middle Fork of Willamette River at Jasper flow non-exceedance compared with NAA**

__Coast Fork of the Willamette Subbasin__

For the Near-Term Operations Measure, the Coast Fork subbasin reservoirs would store more water in the spring and release it during the summer and fall during dry years. They are generally similar to the NAA in wet years. Reservoir elevations would be somewhat higher at both Dorena (Figure 3.2-85) and Cottage Grove for Near-Term Operations Measure during the late spring and summer, with other times similar to the NAA. Figure 3.2-86 shows the control point at Goshen. Since the pools would stay higher throughout the summer, more water would be released during September and October.

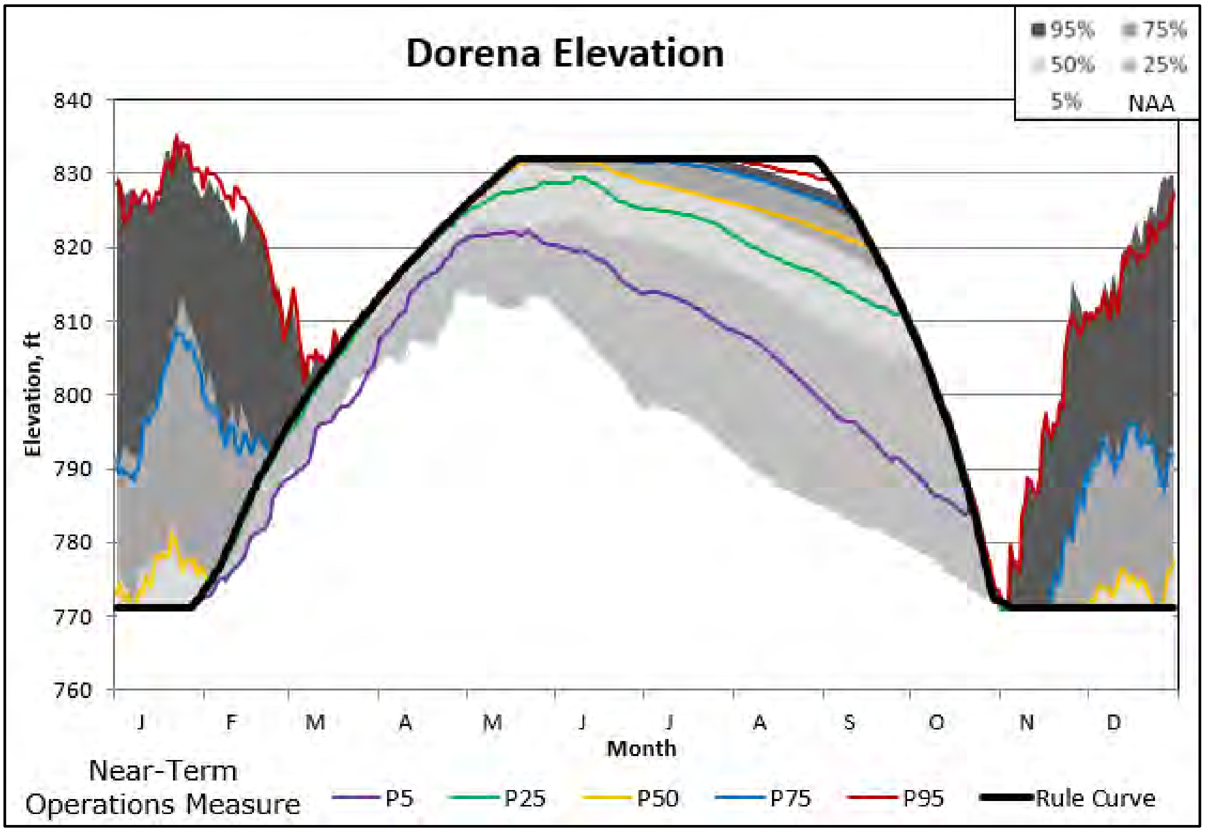



**Figure 3.2-85. Near-Term Operations Measure Dorena water surface elevation non-exceedance compared with NAA**

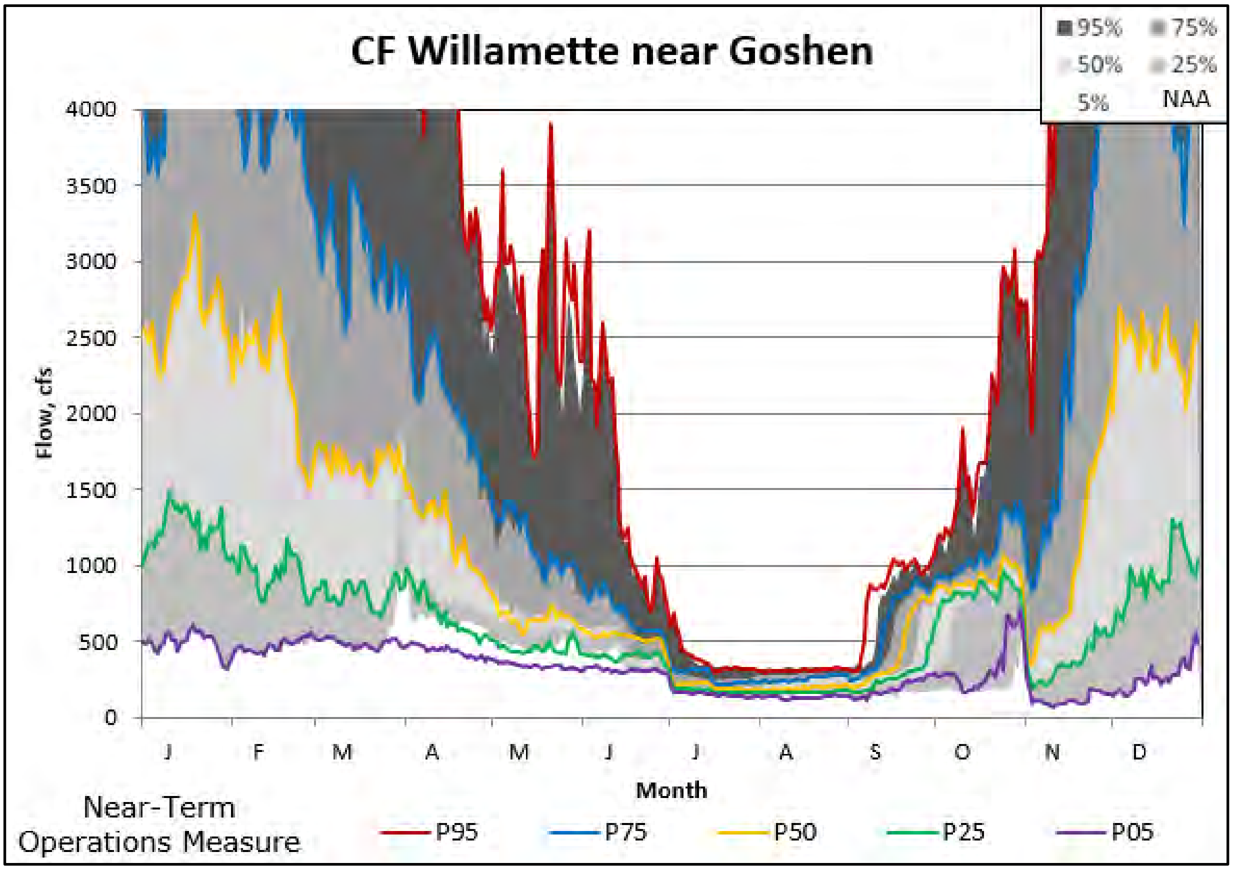



**Figure 3.2-86. Near-Term Operations Measure Coast Fork of Willamette River at Goshen flow non-exceedance compared with NAA**

**Mainstem Willamette River**

The Near-Term Operations Measure flow targets on the mainstem Willamette River at Albany and Salem (Figures 3.2-87 and 3.2-88, respectively) are the integrated temperature and habitat flow regime targets, which are lower than the BiOp targets in the NAA and modify the flow target at Salem during warm weather (the flow target region in the figure). Section 2.2.1, Flow Measures, contains a more detailed explanation of these flow targets.

In wet years, the Near-Term Operations Measure would have consistently higher flow during the springtime at both Albany and Salem as compared to the NAA. The driest years would have lower flow in the spring due to the lower effective flow target at Salem. A decrease in total upstream storage means lower flows across all years at Albany for the Near-Term Operations Measure as compared to the NAA. When the largest upstream reservoirs hit their minimum elevation in September of the driest years (P05 line), flows at Albany would fall below the target and the NAA until Lookout Point releases water for its the deeper fall reservoir drawdown.

If Cougar reservoir were to operate to lower elevations during its delayed refill – instead of being limited to a maximum downstream flow – Albany would miss its flow target more often.

Since most years (P75 line) are already at the flow target for about a month and for longer periods in drier years, removing most of Cougar reservoir's stored water would likely push flows below the target much more often.

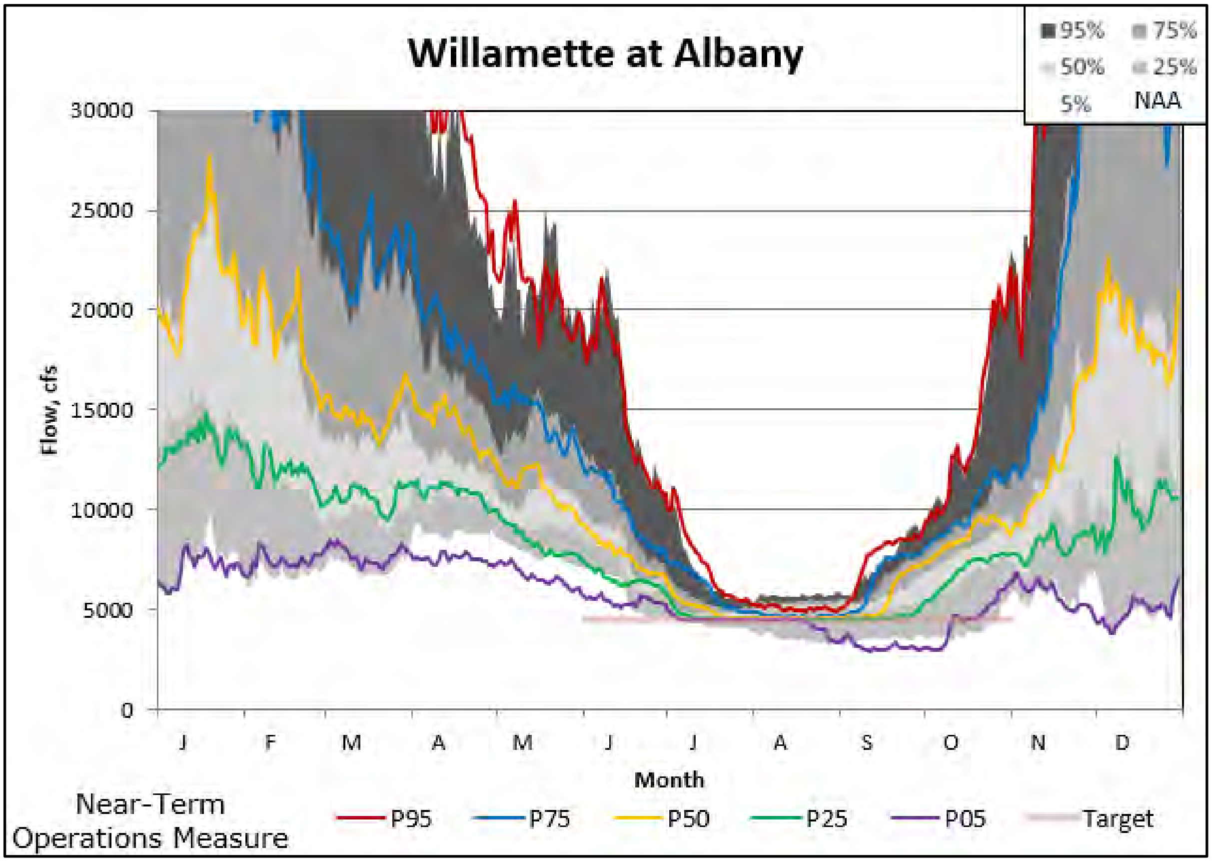



**Figure 3.2-87. Near-Term Operations Measure Willamette River at Albany flow non-exceedance compared with NAA**

Despite the lower targets of the integrated temperature and habitat flow regime, flow at Salem would be fairly similar to the NAA in the spring and summer. Since actual outflows from various dams (e.g., spillway flows at Green Peter) would be higher than would be required to meet minimum flow targets, the flows at Salem would behave similar to the higher BiOp requirements in the NAA for these periods. Detroit Reservoir would have higher storage for the Near-Term Operations Measure than the NAA across all years, so it can supplement the lower storage in the Middle Fork reservoirs. Therefore, Salem would meet its target in the driest years in later summer and early fall while Albany may not. The releases for the deeper fall reservoir drawdowns at Green Peter and Lookout Point would show an increase in flows as compared to the NAA during September and October that would be evident even as far downstream as Salem.

Lower water surface elevations at Cougar Reservoir are not likely to have as much of an effect at Salem as Albany. Detroit Reservoir would remain above its minimum across all years and could likely supplement for some of the Cougar storage reduction downstream of the Santiam's confluence with the mainstem Willamette River.

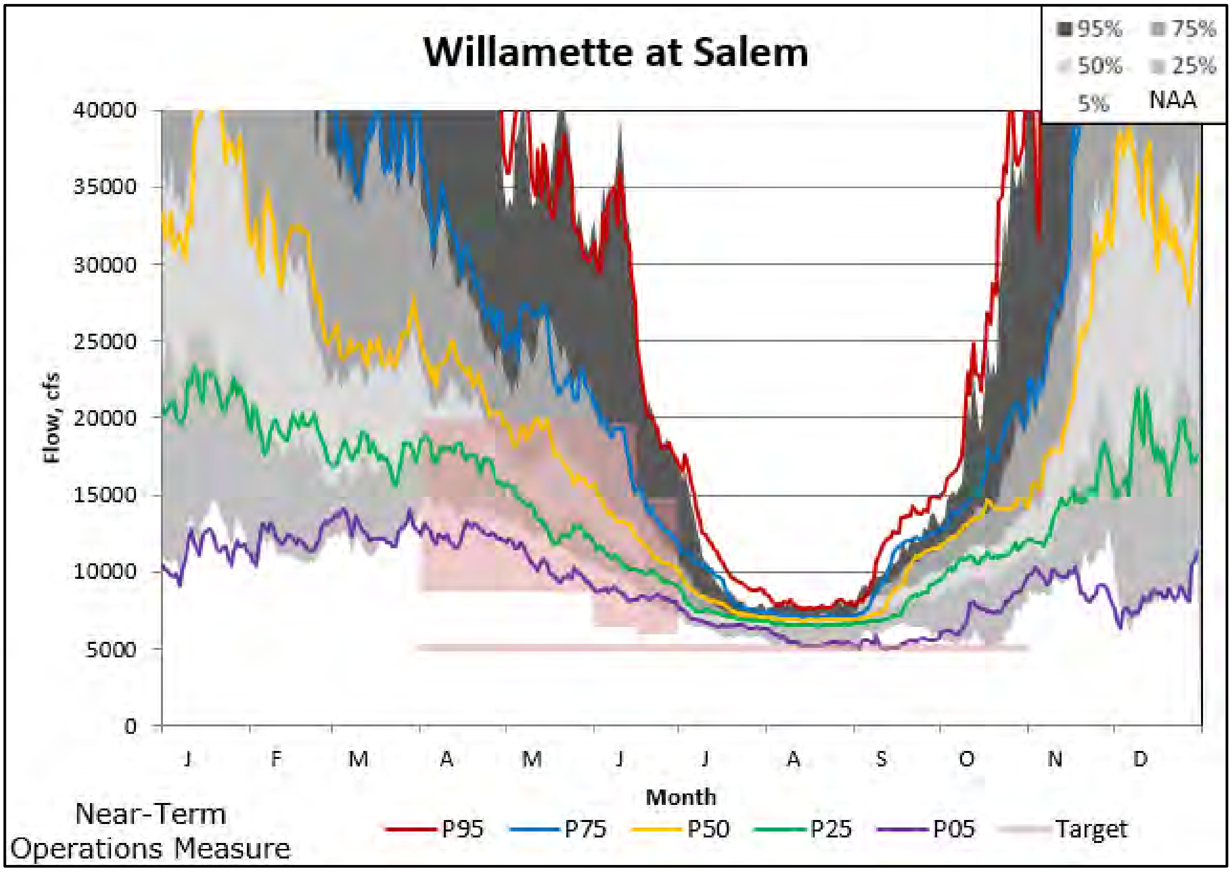



**Figure 3.2-88. Near-Term Operations Measure Willamette River at Salem flow non-exceedance compared with NAA**

### *3.2.2.5.8 Climate Change*

The WVS will likely experience increasing wintertime flow volumes in the future. Some flood magnification (increased severity during flood season) is also likely. Because the WVS system storage will remain about the same, it is likely that FRM operations will face future challenges. An upward shift in winter median future project inflows may increase both the average reservoir water surface elevation as well as outflows downstream of the WVS dams. Reservoirs located within higher elevation subbasins, such as Detroit and Cougar, are likely to see higher rainfall and runoff volumes in the winter. Higher projected temperatures in the future would mean less snowpack than currently experienced. Lower snowpack would also reduce spring volume as the snow melts. Lower elevation subbasin projects such as Fern Ridge and Cottage Grove, with little or no snowpack, are projected to experience higher wintertime flow volumes, but similar peak runoff timing compared to historical baselines.

During conservation season, climate change will affect Alternative 2A similar to the NAA, though Alternative 2A may be able to store and release more water in the spring and summer of dry years as compared to the NAA. Since the Alternative 2A integrated temperature and habitat flow regime minimum targets are lower than the NAA BiOp requirements, the reservoirs can store more water during conservation season as compared to the NAA. However, reservoirs will have to use more of this stored water to meet downstream flow targets with projected increased variability in the spring shoulder months, drier and hotter summers, and lower summer baseflow. Therefore, reservoirs are projected to have lower water surface elevations compared to the baseline.

Reservoirs in Alternative 2A would sometimes reach minimum elevation during the summer, but less often than the NAA, meaning they would be able to augment summer flows for longer than the NAA even with projected decline in late spring and summer flows. The lowest reservoir water surface elevations will occur in the driest years, which would be drier than the WVS currently encounters, as the reservoirs are drafted more to meet downstream flow targets. The WVS would miss the mainstem Willamette flow targets less often under Alternative 2A than the NAA. Climate change effects, and potential implications as discussed above, draw on the climate change projection and trend information provided in the climate change appendices (F1 and F2).

#### *3.2.2.6 Alternative 2B -- Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 2B would shift stored water releases from the spring to the summer and fall, most prominently in dry years. The “Integrated Temperature and Habitat Flow Regime” would replace the 2008 NMFS BiOp in the NAA. Briefly, this would modify the BiOp targets at a WVS reservoir if it is at more or less than 90 percent of rule curve elevation. Flows would be reduced within a range down to minimums needed for fish survival when reservoirs are under the 90 percent threshold. While these minimums would be less the BiOp targets, these would be adaptive within a water year and can return to return to levels higher than the BiOp flows downstream of the dams if reservoir levels rise about 90 percent full.

At the mainstem Willamette control points – Albany and Salem – flow targets would be reduced to 4,500 and 5,000 cfs, respectively. The higher BiOp targets, particularly in the spring and early summer, are designed to help migrating fish and keep the river from getting too hot, so much more water would be added in the spring. As a replacement, the integrated temperature and habitat flow regime would require additional flow based on the air temperature, with total flow minimum at Salem ranging from 5,900 cfs to 19,800 cfs. This would allow the WVS to store additional water when it is not needed to keep the river, and fish in it, cool.

Alternative 2B would alter storage in drier than average years, and especially the 25 and 5 percent non-exceedance (P25 and P05 in the figures) years, shifting flow releases from April to June into July through October. Flows would be lower than NAA flows in the year during the April to June period. Later flow targets from July to October would be met more frequently due to the additional accumulated stored water. Compared to NAA, the spring and early flows would be similar or somewhat lower across the WVS, so reservoir elevations would be somewhat higher than the NAA throughout the conservation season.

Cougar and Green Peter reservoirs have drawdowns in Alternative 2B. Cougar releases waters down to the diversion tunnel elevation in both spring and fall and Green Peter has a deeper fall reservoir drawdown. During these drawdowns there is more flow downstream of these two reservoirs as compared to the NAA.

Since the spring reservoir drawdown at Cougar occurs during the NAA refill period, storage at Cougar is reduced. As compared to Alternative 2A, which would not draw down Cougar, the reduced storage means that other WVS reservoirs, notably in the Middle Fork of the Willamette River subbasin, are required to release additional water to meet mainstem Willamette River flow targets. Regardless, the flow target at Albany is missed more often in dry years as the larger WVS reservoirs reach their minimum elevations earlier in the year.

Although there are structural actions in Alternative 2B at the WVS dams to aid fish survival, many of these do not affect the flow out of any WVS dam. These do not appear in the reservoir flow model. An example of this is the WTC tower at Detroit, which allows for greater control of the temperature of the water released from the dam but does not alter the flowrate or outlet used for dam operations. A more detailed analysis of Alternative 2B by subbasin follows.

Lower spring flows in dry years and higher summer flows in nearly all years would have long term effects on the WRB. Effects from the Alternative 2B to hydrologic processes: Major compared to the NAA.

##### *3.2.2.6.1 Santiam Subbasin*

Alternative 2B would fill Detroit Reservoir more often and narrow the range of reservoir elevations prior to drafting the reservoir for flood season (Figure 3.2-89) compared to the NAA. The lower tier of the integrated temperature and habitat flow regime requires lower flows downstream of Detroit, so the reservoir would be able to fill more often and has more volume to supply to downstream targets later in the year, meeting all its immediate downstream flow targets across all years.

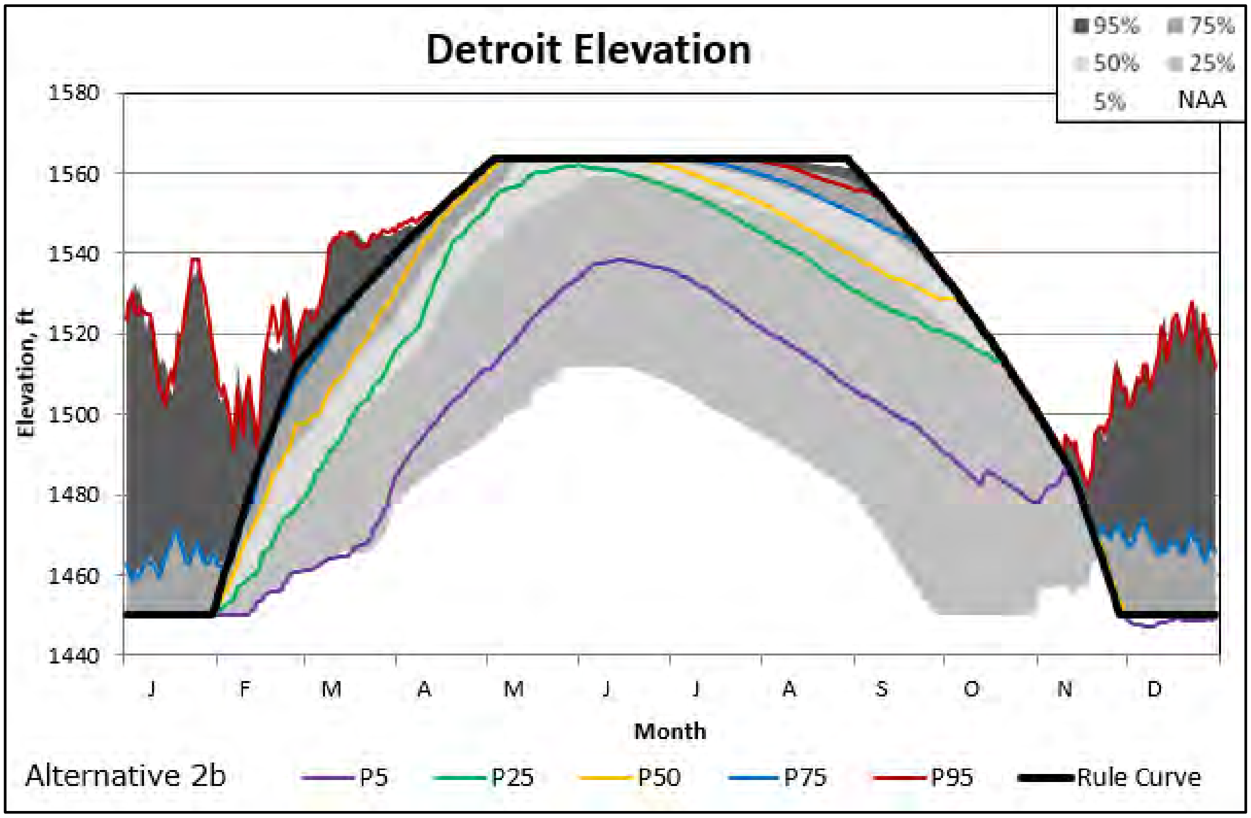



**Figure 3.2-89. Alternative 2B Detroit water surface elevation non-exceedance compared with NAA**

Green Peter reservoir (Figure 3.2-90) would also fill more often during conservation season in Alternative 2B as compared to the NAA, despite implementation of a deeper fall reservoir drawdown. In very dry years, the reservoir elevation would be well below the rule curve through the winter but would recover to higher levels than the NAA by summer due to the lower integrated temperature and habitat flow regime targets. However, the percentage of time that Green Peter reaches top of conservation storage would remain about the same since all inflow above that level would be released from the reservoir. Lower reservoir levels would be expected throughout the winter flood season, even during the wettest years.

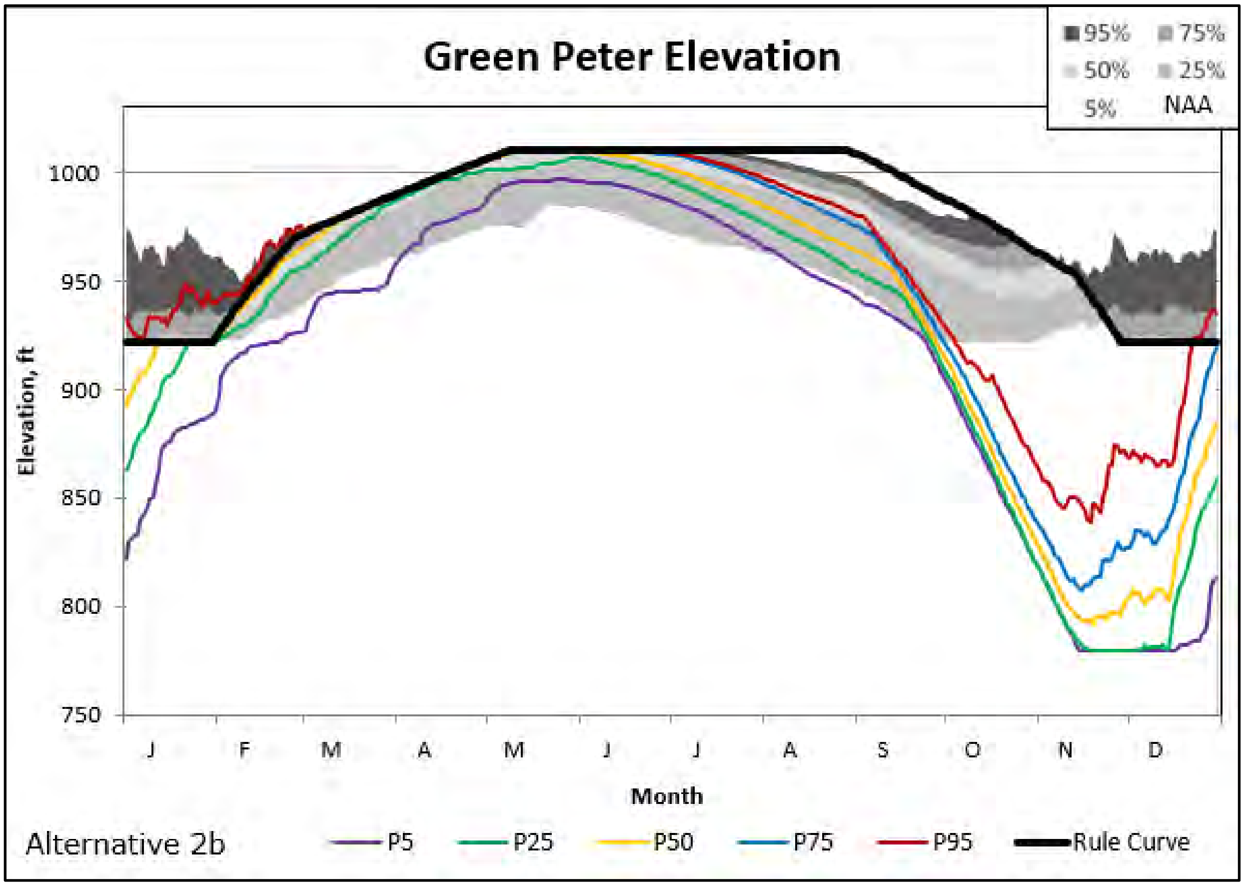



**Figure 3.2-90. Alternative 2B Green Peter water surface elevation non-exceedance compared with NAA**

Outflow from Foster Dam (Figure 3.2-91) would meet the integrated temperature and habitat flow regime targets except in November of very dry years when Green Peter would have already reached the minimum deeper fall reservoir drawdown elevation. The increased flows in September are the result of Green Peter releasing water for the deeper fall reservoir drawdown. Immediately downstream, winter flows across all but very wet years would be lower. This is also due the Green Peter deeper fall reservoir drawdown, as it holds back water to get back up to minimum conservation pool. Foster Reservoir would seldom deviate from the rule curve – and the NAA – for Alternative 2B.

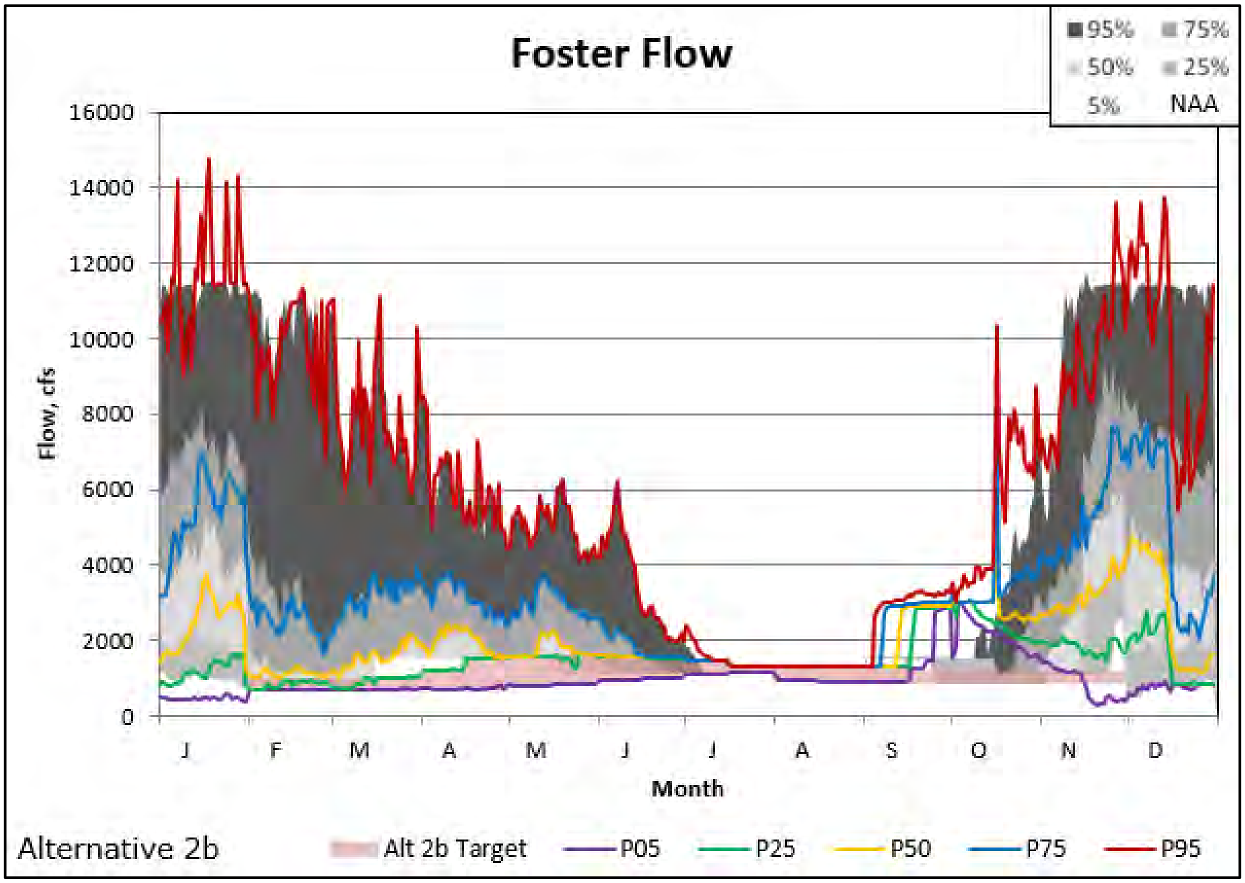



**Figure 3.2-91. Alternative 2B Foster flow non-exceedance compared with NAA**

The Santiam at Jefferson (Figure 3.2-92) would show some of the flow changes at Foster but any potential winter flood management benefits from the deeper fall reservoir drawdown at Green Peter would no longer be present. Wet weather flows would be very similar to the NAA during the winter and lower flows would be only slightly lower, though these flows are already well below flood stage. In the spring, lower flows in the driest years would be due to the lower requirements of the integrated temperature and habitat flow regime, both directly downstream of the dams and mainstem flow targets. Detroit, with its higher storage volumes, can supply water throughout the summer, resulting in higher flows than the NAA. The increased flows in September from the Green Peter deeper fall reservoir drawdown would be evident at Jefferson.

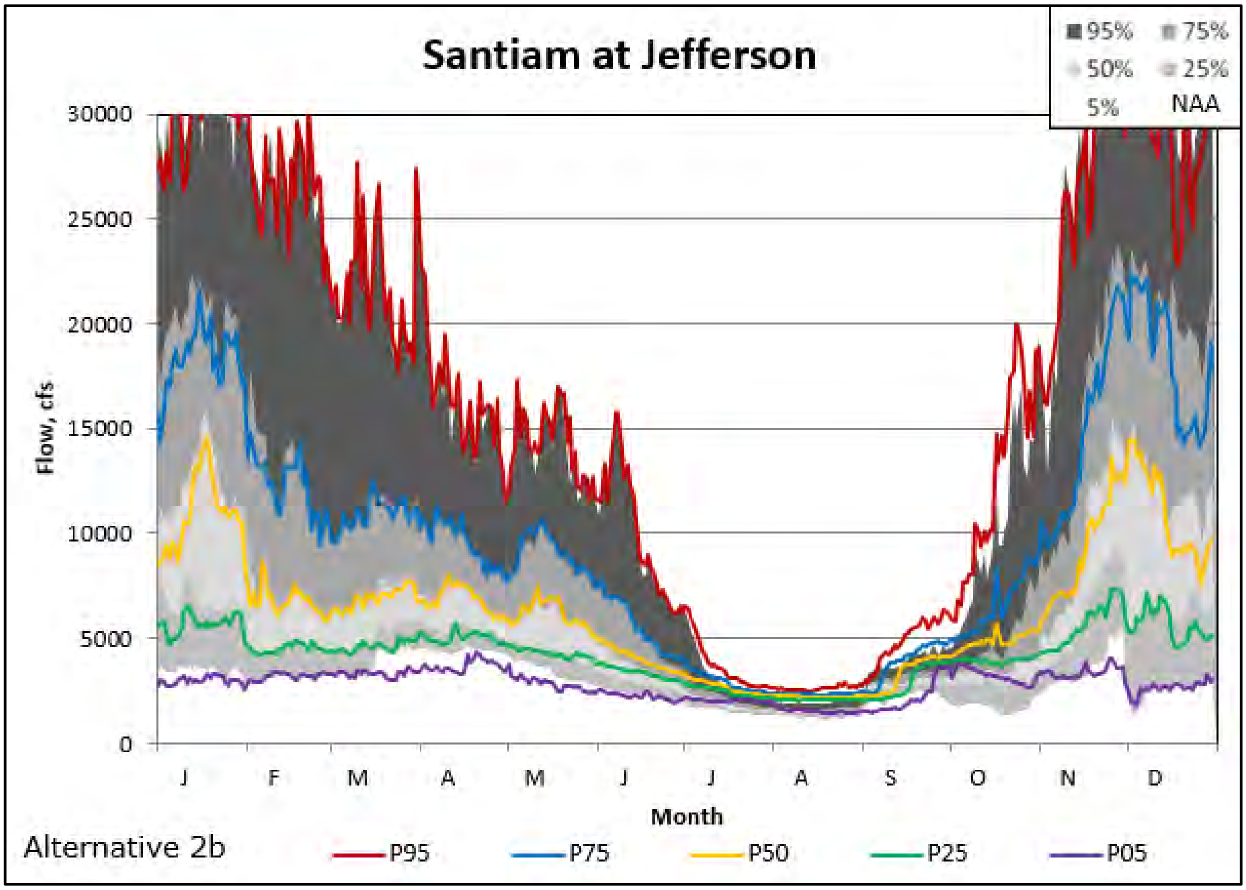



**Figure 3.2-92. Alternative 2B Santiam at Jefferson flow non-exceedance compared with NAA**

#### *3.2.2.6.2 Long Tom Subbasin*

As explained in the NAA, Fern Ridge reservoir (Figure 3.2-93) is operated for recreation and fish and wildlife habitat in the conservation season and typically seeks to maximize the reservoir pool during the summer. Since Fern Ridge has a large surface area and small volume compared to the other WVS reservoirs, there is limited scope to change its operation and the water surface elevations within Fern Ridge would remain nearly the same as the NAA. Downstream flows at Monroe would remain similarly unchanged for Alternative 2A.

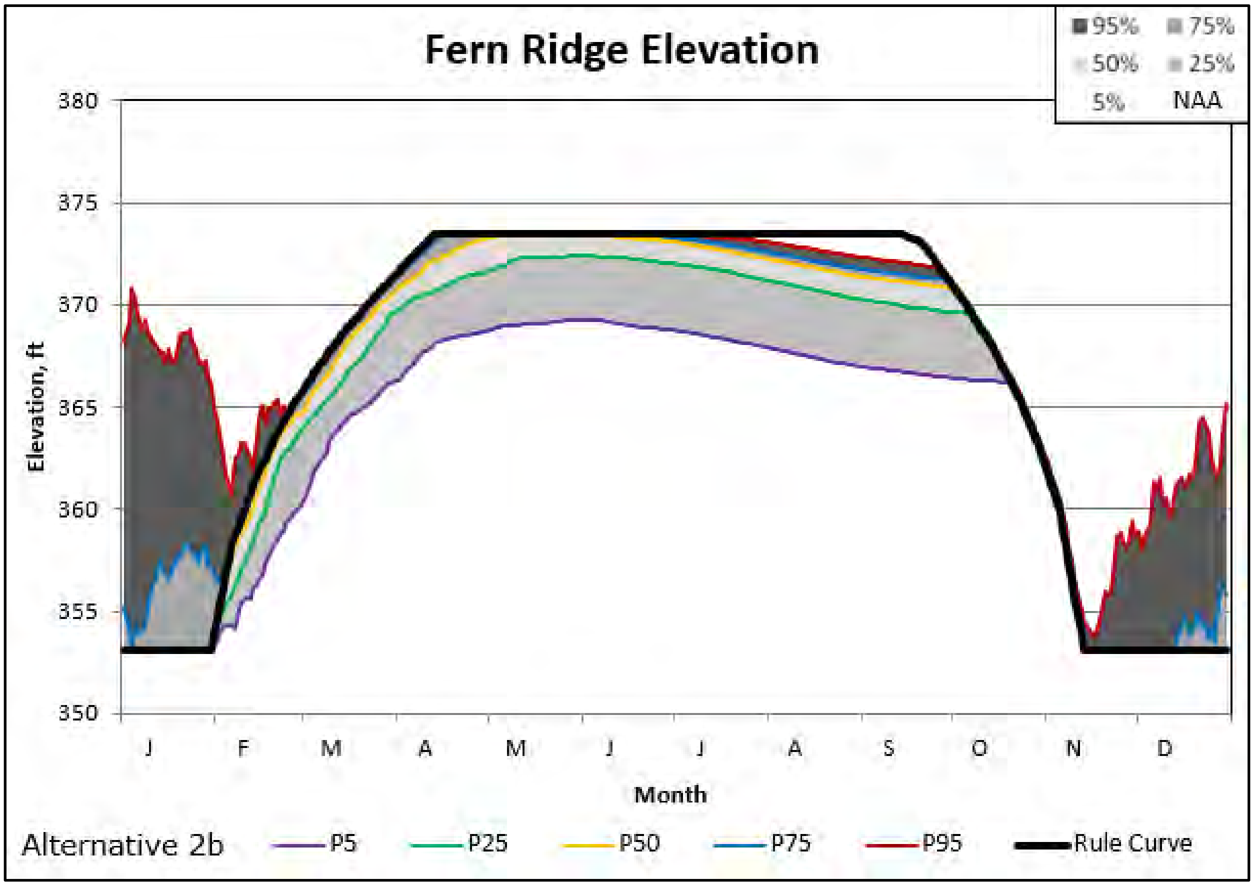



**Figure 3.2-93. Alternative 2B Fern Ridge water surface elevation non-exceedance compared with NAA**

#### *3.2.2.6.3 McKenzie Subbasin*

Cougar reservoir (Figure 3.2-94) would have both a spring and fall reservoir drawdown in Alternative 2B, down to 1330 feet. This is a significant change from the NAA. The reservoir water surface elevation would only be at or above minimum conservation pool at the end of winter and only the wettest summers (P95 line). An average year (P50) would achieve the spring reservoir drawdown target elevation, but would not during the fall. Cougar would also miss its downstream flow target when it is at minimum elevation during the summer and fall, sometimes for many months.

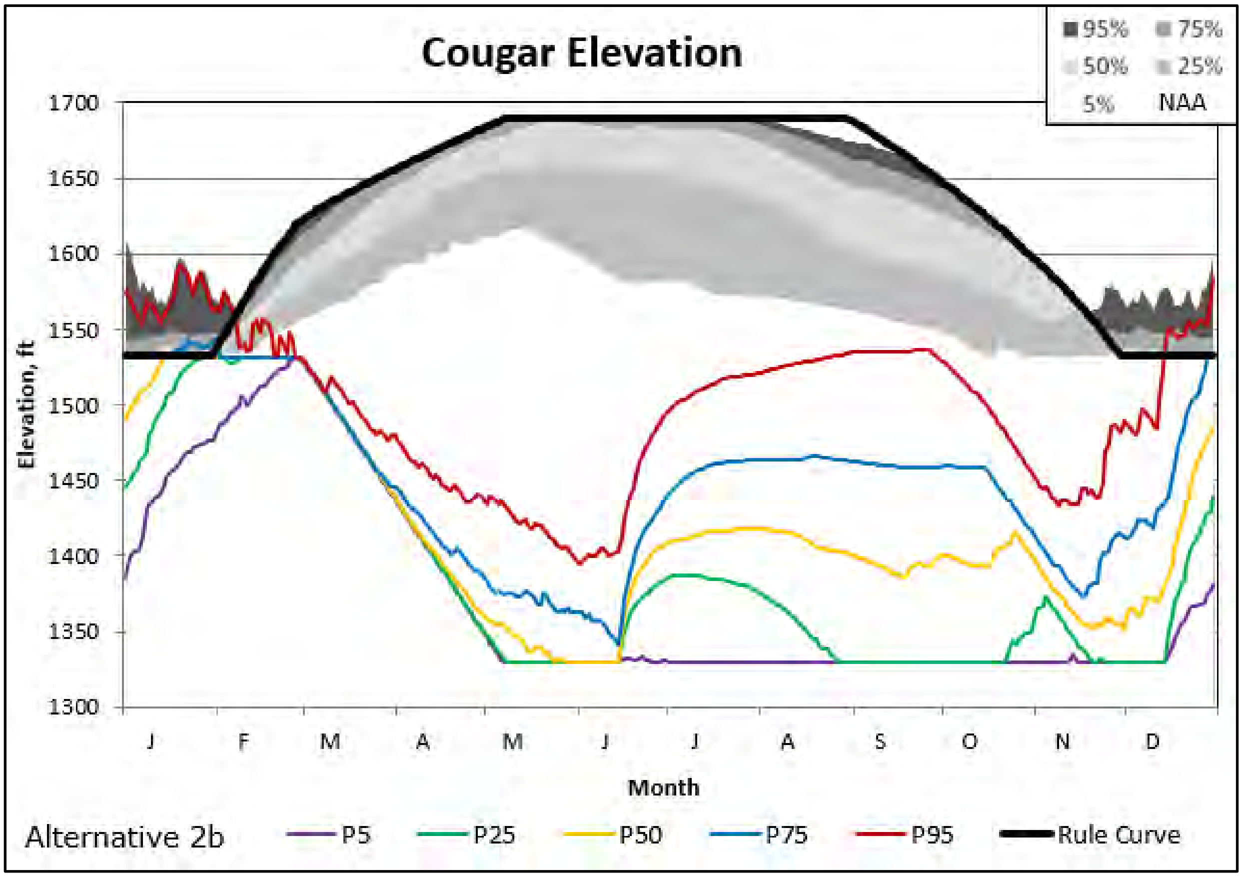



**Figure 3.2-94. Alternative 2B Cougar water surface elevation non-exceedance compared with NAA**

Blue River reservoir (Figure 3.2-95) would fill more often as compared to the NAA and uses the inactive pool to supplement downstream flow targets during October of the driest years. There are two changes due to the Cougar diversion tunnel operation, as compared to Alternative 2A. Blue River would be required to store more water during very wet years for the McKenzie River at Vida to remain at or below bankfull since Cougar is drafting for the spring reservoir drawdown. Additionally, Blue River would augment instream flows by using the power pool more often during the fall of very dry years, since Cougar would not have any accumulated storage during those times.

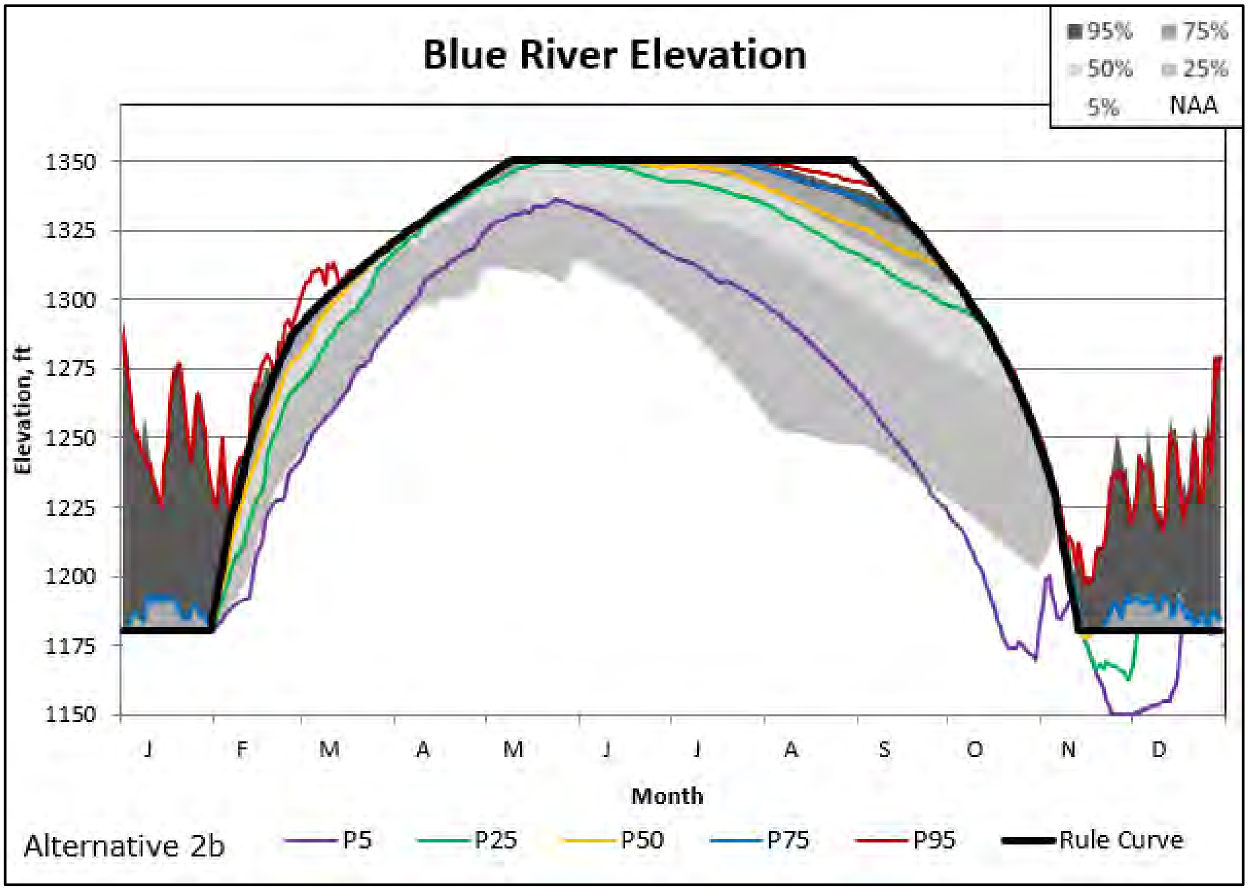



**Figure 3.2-95. Alternative 2B Blue River water surface elevation non-exceedance compared with NAA**

Moving downstream to the control point for both Cougar and Blue River, the McKenzie River at Vida (Figure 3.2-96) would show the effect of the Cougar reservoir drawdowns. The higher flows in the spring would be from Cougar's releases to reach the diversion tunnel elevation. Lower flows starting in June would be the result of Cougar having reduced storage throughout conservation season which would not occur under the NAA. Notably, flow would be only slightly less in the driest years as compared to the NAA due to additional flow from Blue River. However, as compared to Alternative 2A, in which dry-year flows would be above the NAA, flows would be reduced through the summer and fall.

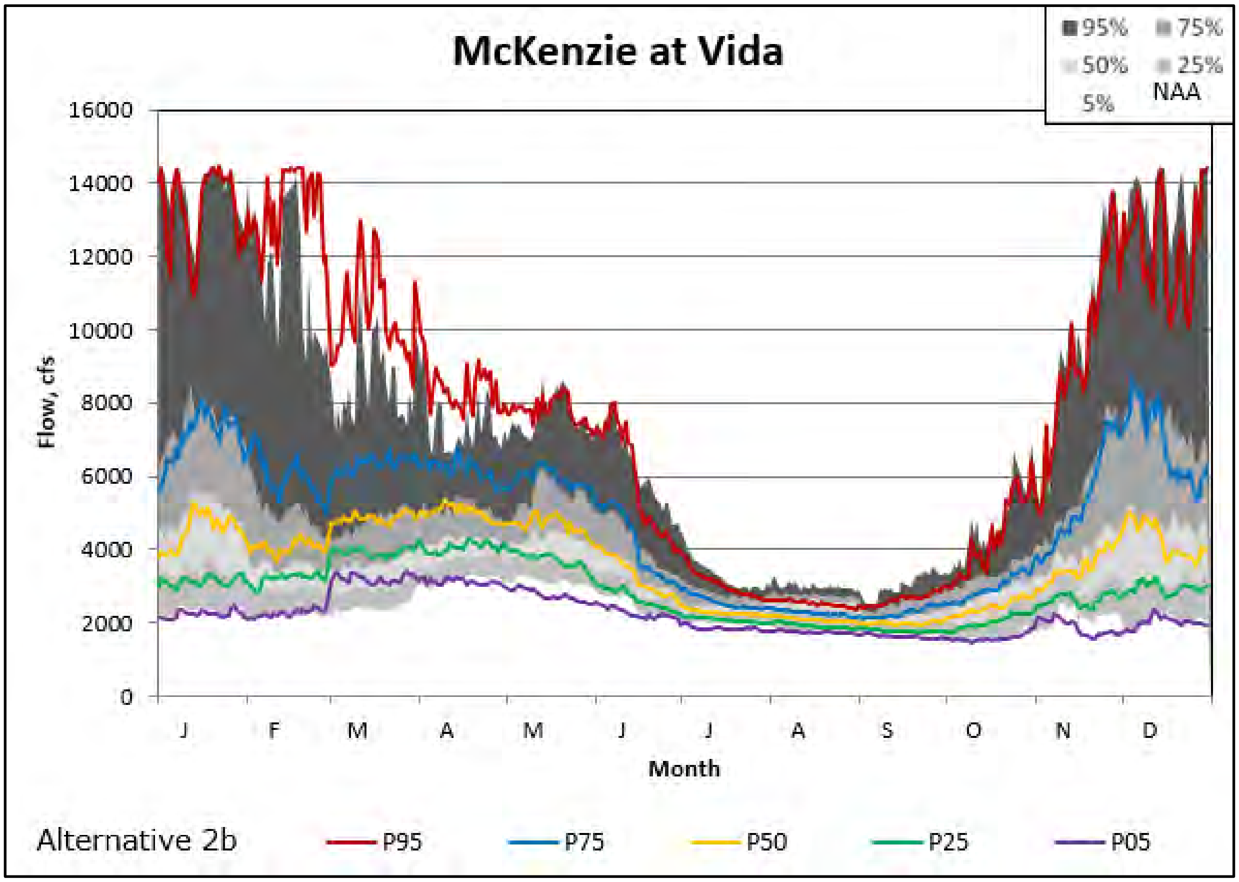



**Figure 3.2-96. Alternative 2B McKenzie River at Vida flow non-exceedance compared with NAA**

### *3.2.2.6.4 Middle Fork of the Willamette Subbasin*

Hills Creek (Figure 3.2-97) initially would fill more quickly due to the lower integrated temperature and habitat flow regime targets and would stay at similar or higher elevations during wet years compared to the NAA. During dry years, the reservoir would augment instream flows by using the power pool, releasing more water to meet the flow target at Albany. Its capacity would be exhausted in the driest years (P05 line), at which point Lookout Point would supply additional water and reach its Alternative 2B minimum in Figure 3.2-98. As compared to Alternative 2A, storage elevations for both Hills Creek and Lookout Point would be slightly lower across all years. Since Cougar has much less storage in Alternative 2B, both reservoirs would release more water to meet mainstem flow targets.

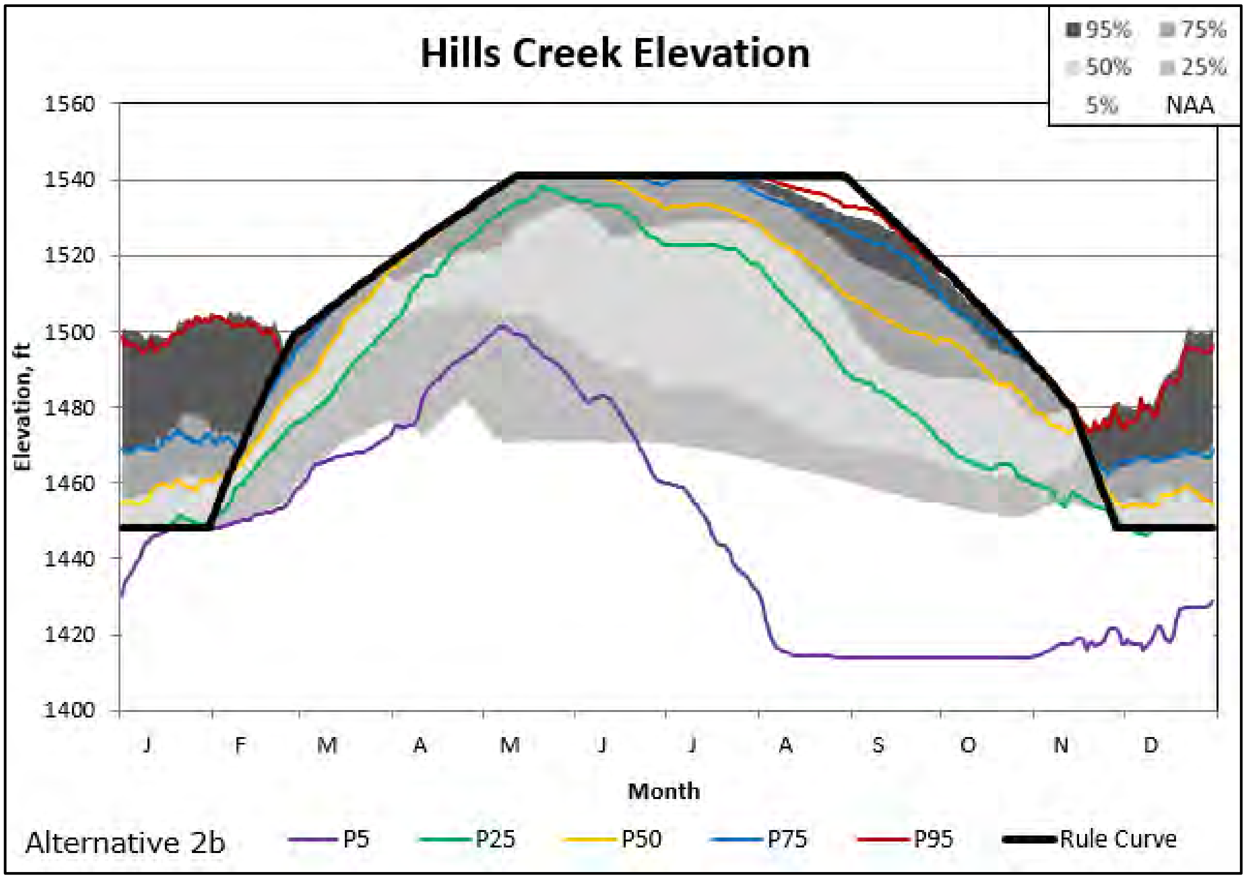



**Figure 3.2-97. Alternative 2B Hills Creek water surface elevation non-exceedance compared with NAA**

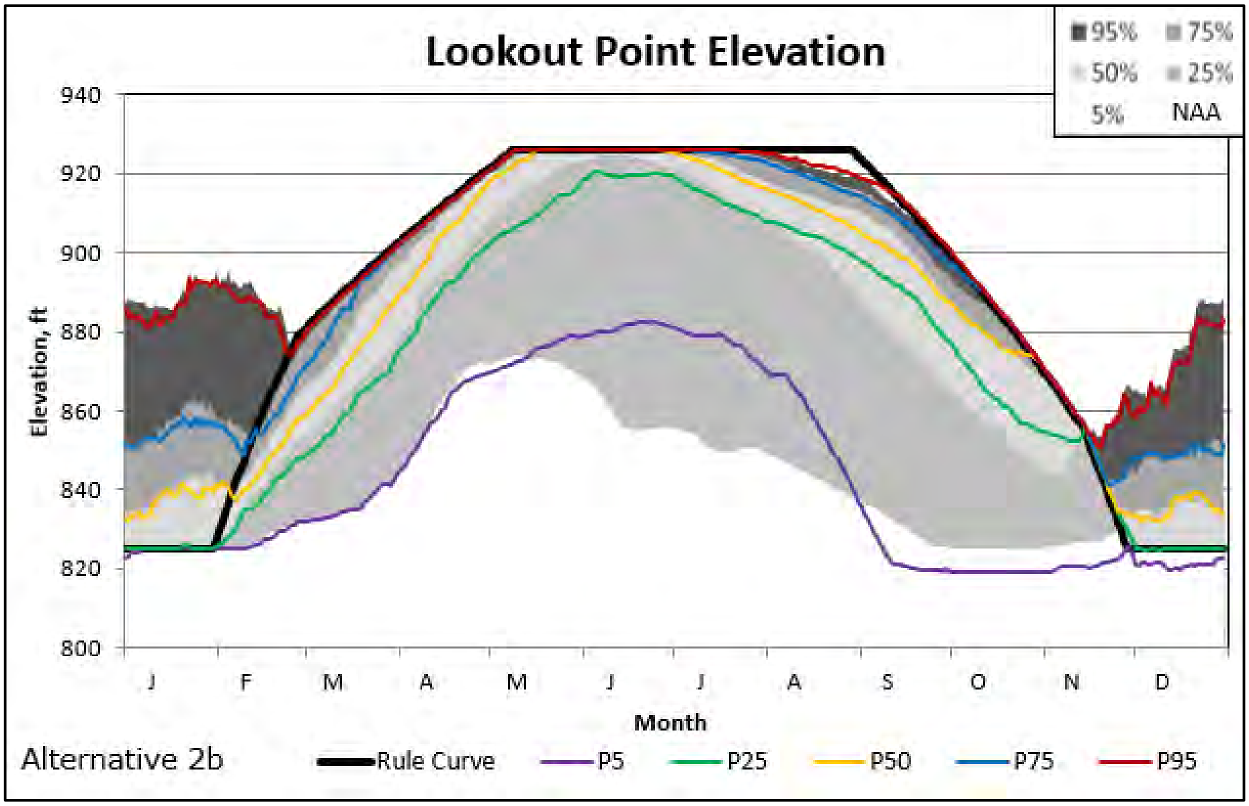



**Figure 3.2-98. Alternative 2B Lookout Point water surface elevation non-exceedance compared with NAA**

Fall Creek reservoir (Figure 3.2-99) would show only marginal differences from the NAA in Alternative 2B, though some elevations would be somewhat below those in Alternative 2A.

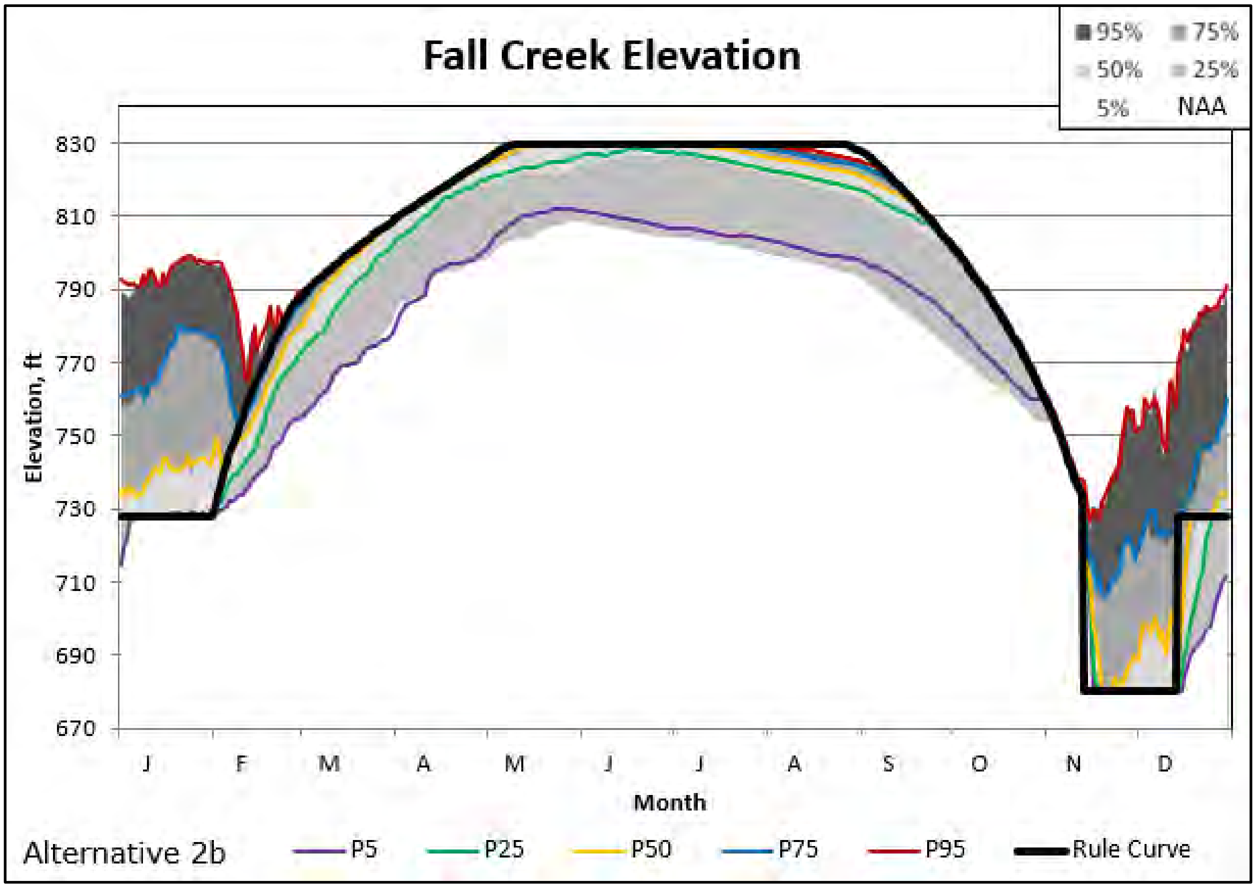



**Figure 3.2-99. Alternative 2B Fall Creek water surface elevation non-exceedance compared with NAA**

At the downstream control point at Jasper (Figure 3.2-100), the shift in flow releases would be evident, especially in dry years, with lower flows in the spring and higher flows in the summer and fall compared to the NAA. The increased fall flows during wet years as compared to the NAA would be due to the reservoirs starting at a higher elevation prior to drafting for flood season. There would be more water to release from the reservoirs so there would be higher flow downstream of them.

In the fall of the driest years (P05 line), flows would be lower than Alternative 2A and sometimes below the NAA. Both Hills Creek and Lookout Point would reach their minimum elevations and only release inflow. Lower storage at Cougar Reservoir would require higher releases from the Middle Fork WVS reservoirs to meet downstream flow targets. Since Lookout Point would already reach its minimum in Alternative 2A, the additional flow requirements would be enough to reach that level in the driest years in Alternative 2B.

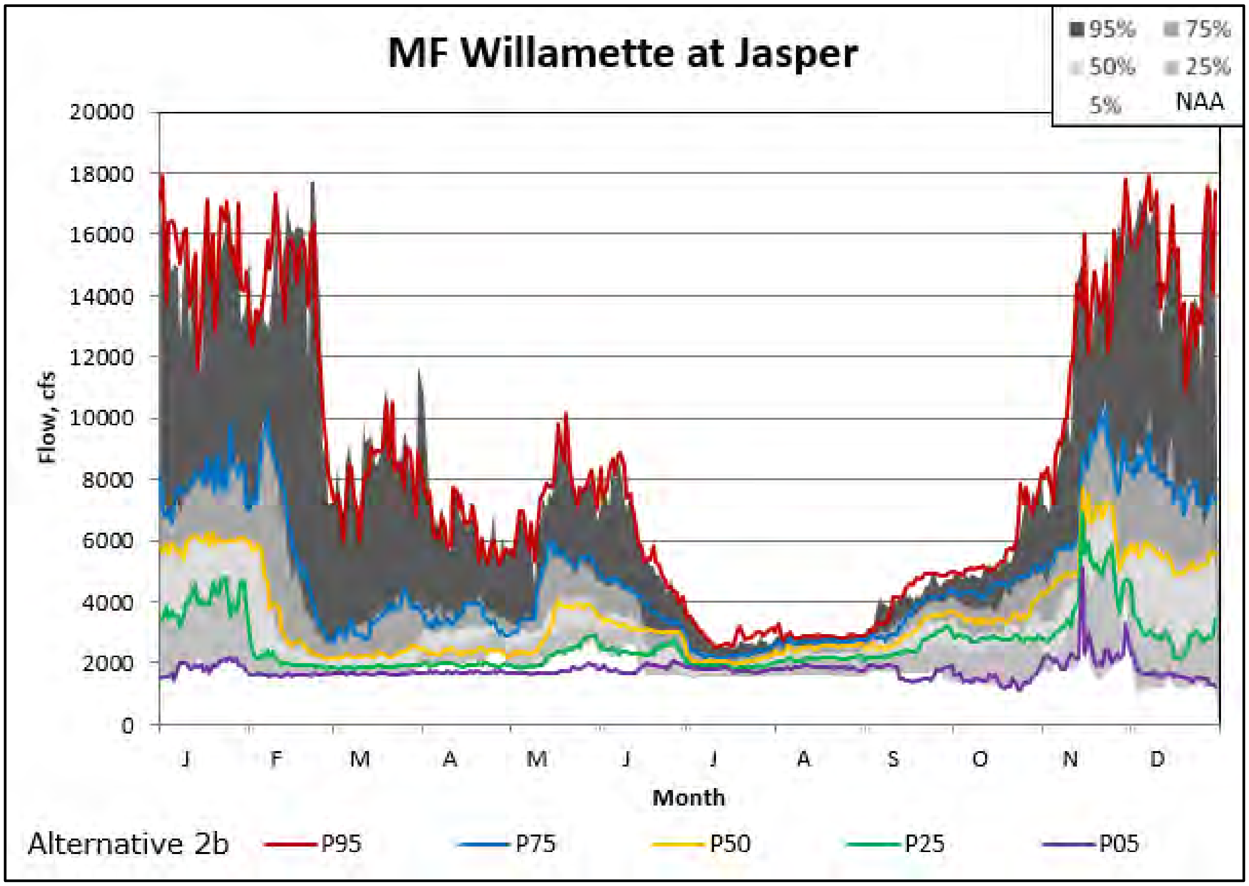



**Figure 3.2-100. Alternative 2B Middle Fork of the Willamette River at Jasper flow non-exceedance compared with NAA**

*3.2.2.6.5 Coast Fork of the Willamette Subbasin*

For Alternative 2B, the Coast Fork subbasin would store more water in the spring and release it during the summer and fall during dry years and it would be generally similar to the NAA in wet years. Reservoir elevations would be somewhat higher at both Dorena (Figure 3.2-101) and Cottage Grove for Alternative 2B during the late spring and summer, with other times similar to the NAA. Figure 3.2-102 shows the control point at Goshen. Since the pools would stay higher throughout the summer, more water would be released during September and October compared to the NAA.

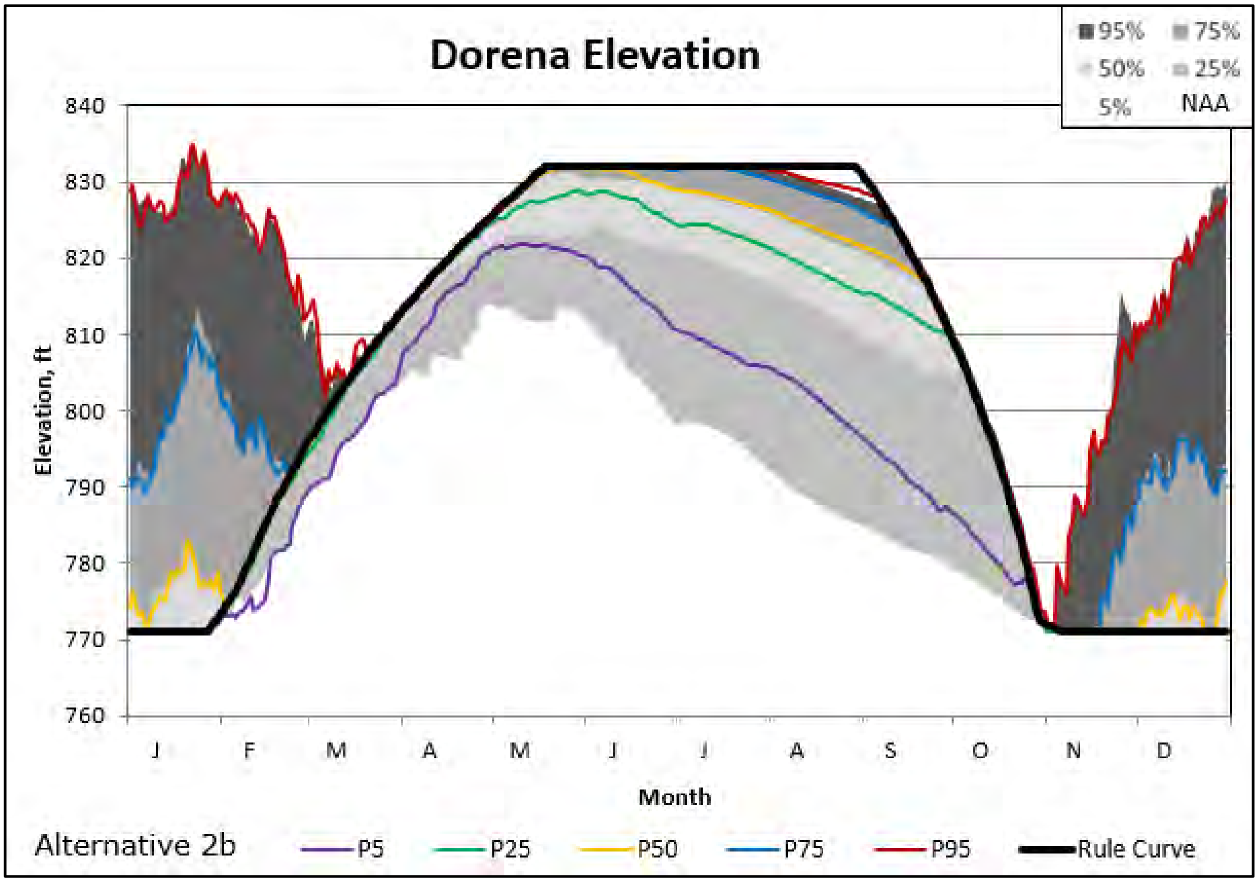



**Figure 3.2-101. Alternative 2B Dorena water surface elevation non-exceedance compared with NAA**

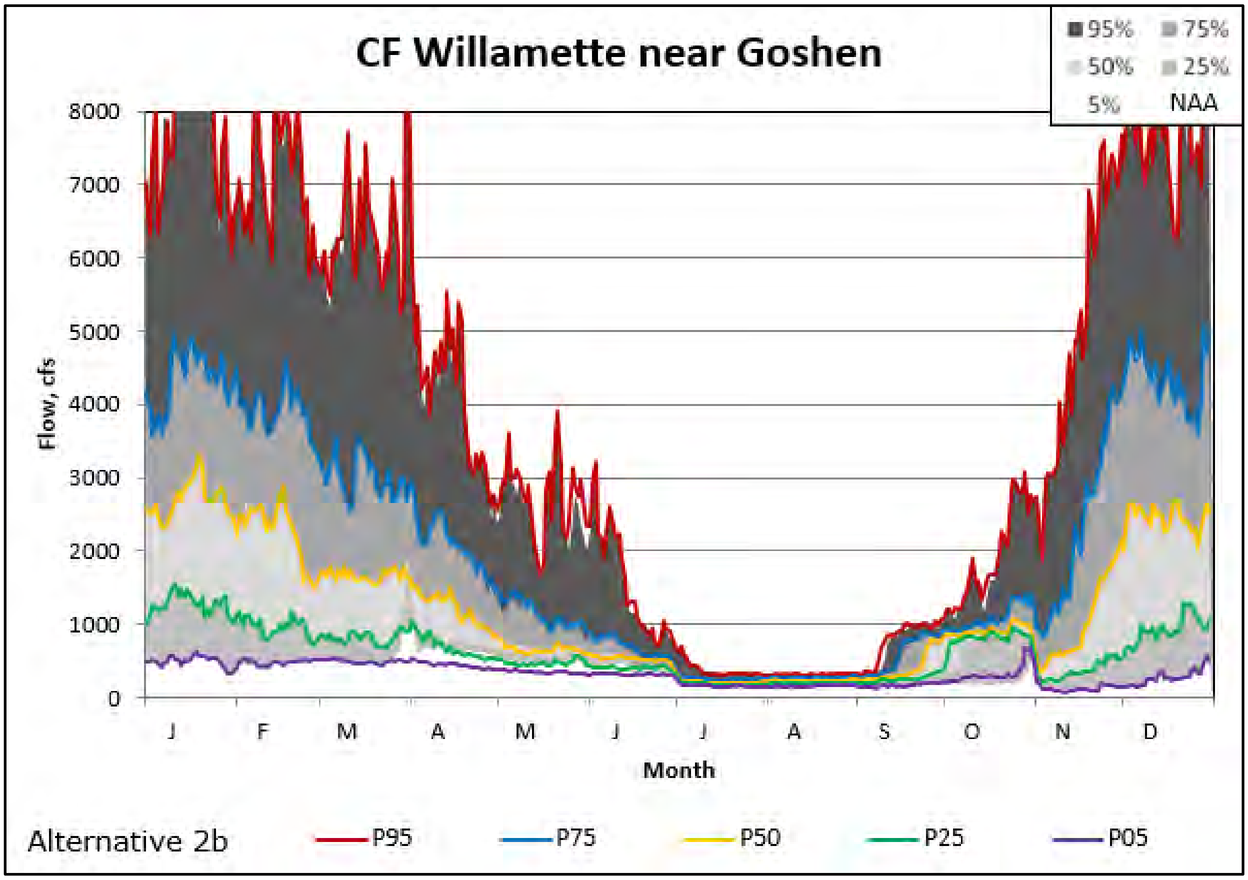



**Figure 3.2-102. Alternative 2B Coast Fork of the Willamette River at Goshen flow non-exceedance compared with NAA**

### *3.2.2.6.6 Mainstem Willamette River*

Alternative 2B would alter the regulated hydrology of the mainstem Willamette River control points, storing water more water in the spring and releasing it during the summer. The Willamette River at Albany (Figure 3.2-103) would show dry years below their NAA equivalents from April to June and a compressed flow regime through the summer, with the higher flow years reduced and the low flow years increased. The WVS would typically meets the lower integrated temperature and habitat flow regime target at Albany, missing during September and October of the driest years. Albany would be below the Alternative 2B target for much more time than the same target during Alterative 2A due to the decreased contributions from Cougar reservoir.

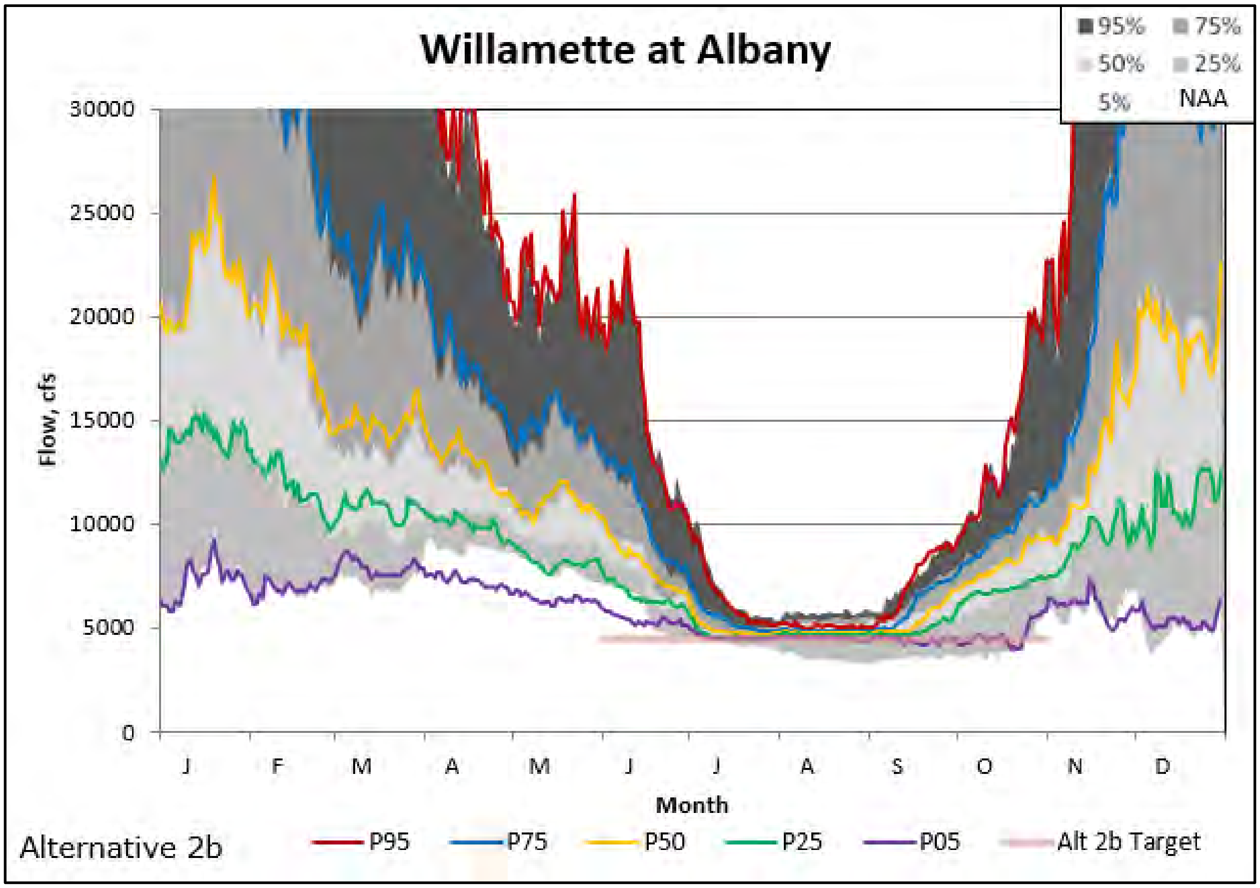



**Figure 3.2-103. Alternative 2B Willamette River at Albany flow non-exceedance compared with NAA**

Like the Albany control point, the Willamette River at Salem (Figure 3.2-104) would show reduced flows from April to June of dry years, while meeting the integrated temperature and habitat flow regime variable air-temperature-guided target. Summer and fall flows would increase across all years as compared to the NAA, though slightly decreased as compared to Alternative 2A. The effect of reduced storage at Cougar would be much less evident at Salem due to the contributions of the Santiam WVS reservoirs and the integrated temperature and habitat flow regime target would nearly always be met.

The increased flows from September to November would be due to the deeper fall reservoir drawdown at Green Peter compared to the NAA. These increases would be within the river channel (up to 90,000 cfs), meaning they would not impact flood risk.

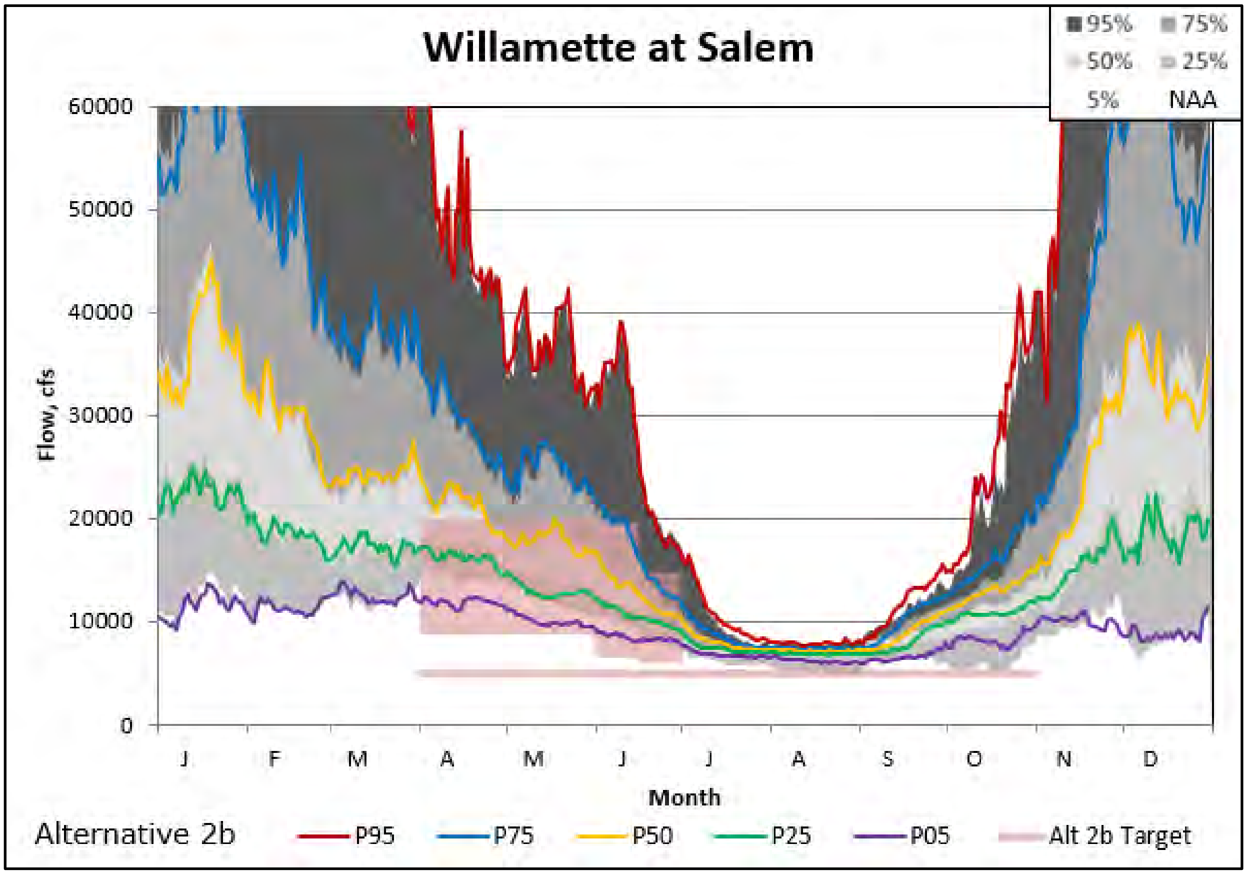



**Figure 3.2-104. Alternative 2B Willamette River at Salem flow non-exceedance compared with NAA**

### *3.2.2.6.7 Near-Term Operations Measure*

See Alternative 2A, Section 3.2.2.4.7, for description of effects due to the Near-Term Operations Measure.

### *3.2.2.6.8 Climate Change*

The WVS will likely experience increasing wintertime flow volumes in the future. Some flood magnification (increased severity during flood season) is also likely. Because the WVS system storage would not increase substantially, it's likely that FRM operations will face future challenges. An upward shift in winter median future project inflows may increase both the average reservoir water surface elevation as well as outflows downstream of the WVS dams. Both Green Peter and Cougar would refill to their conservation pool elevation later in the year after their deeper fall reservoir drawdowns. However, the overall potential benefit may be minimal to future FRM operations. While the lower reservoir elevation at Cougar at the start of flood season is potentially helpful, the storage volume below the minimum conservation elevation is much less than that above it and climate-driven conversion from snowfall to rain may be more impactful than the additional storage. At Green Peter, projections for flow changes are more muted than the higher elevation basins, meaning that it may diminish in importance relative to other WVS reservoirs for FRM operations.

Reservoirs located within higher elevation subbasins, such as Detroit, are likely to see higher rainfall and runoff volumes in the winter. Higher projected temperatures in the future will mean less snowpack than currently experienced. Lower snowpack would also reduce spring volume as the snow melts. Lower elevation subbasin projects such as Fern Ridge and Cottage Grove, with little or no snowpack, are projected to experience higher wintertime flow volumes, but similar peak runoff timing compared to historical baselines.

During conservation season, climate change will affect Alternative 2B similar to Alternative 2A, with the main difference being lower reservoir elevations in the McKenzie and Middle Fork of the Willamette River subbasins and lower flow in the McKenzie River. Since the Alternative 2B integrated temperature and habitat flow regime targets are lower than the NAA BiOp requirements, most WVS reservoirs can store more water during conservation season as compared to the NAA. However, those reservoirs will have to use more of this stored water to meet downstream flow targets with projected increased variability in the spring shoulder months, drier hotter summers, and lower summer baseflow. Outside of flood season, Cougar reservoir would likely never fill to minimum conservation elevation due to decreased inflow after its spring reservoir drawdown to the diversion tunnel which does not occur under the NAA. Hills Creek and Lookout Point would have to release more water to meet the Albany flow target, substituting for the lack of releases available from Cougar.

Across the WVS, reservoirs are projected to have lower water surface elevations as compared to the baseline, though Cougar, Hills Creek, and Lookout Point are most affected. Reservoirs in Alternative 2B would sometimes draft to minimum targeted elevation during the summer, but less often than the NAA, meaning they would be able to augment summer flows for longer than the NAA even with projected decline in late spring and summer flows. The lowest reservoir water surface elevations would occur in the driest years, which would be drier than the WVS currently encounters, as the reservoirs are drafted more to meet downstream flow targets. The WVS would miss the mainstem Willamette flow target at Albany more often under Alternative 2B than Alternative 2A due the reduced system storage, but more often than the NAA. The flow target at Salem under Alternative 2B would remain similar to Alternative 2A since inflow from the Santiam subbasin would reduce the impact storage deficit at Cougar. Climate change effects, and potential implications as discussed above, draw on the climate change projection and trend information provided in the climate change appendices (F1 and F2).

#### *3.2.2.7 Alternative 3A – Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)*

Alternative 3A would primarily use WVS dam operations for fish passage within the WRB and not use structural modifications as in Alternatives 1 and 4. An important part of this is the increased use of different flow outlets from the dams to control temperature, with the spillway supplying warmer water from the upper reservoir and the deeper outlets – ROs and turbines –

supplying cooler water. Although these different outlet flows are calculated in the regulation model, they are not generally going to show up in the standard charts presented here, since they compare total flow with the NAA. The effects of those outlet flow changes – for example, temperature and TDG differences – will show up as inputs to other modeling, such as the temperature and biological models see Section 3.5.

Alternative 3A would also allow reservoirs augment instream flows by using the inactive or power pools, drafting below the NAA rule curves to meet minimum flow requirements. This would most frequently occur during the fall of drier years at reservoirs that do not have a deeper fall reservoir drawdown operation.

The primary set of flow targets are the "Integrated Temperature and Habitat Flow Regime," which replace the 2008 NMFS BiOp targets in the NAA. Briefly, the integrated temperature and habitat flow regime has two sets of bi-weekly targets at a WVS reservoir, each set for whether the reservoir is higher or lower than 90 percent of rule curve elevation. Flows are reduced within a range down to minimums needed for fish survival when reservoirs are under the 90 percent threshold. However, these are adaptive within a water year and can return to levels higher than the NAA 2008 BiOp flows downstream of the dams if reservoir levels increase.

Alternative 3A would implement spring and fall reservoir drawdowns at some WVS reservoirs for volitional downstream fish passage. The spring reservoir drawdown operations are at Detroit, Lookout Point and Cougar (to the regulating outlet) and the deeper fall reservoir drawdown operations are at Blue River, Hills Creek, Green Peter, Detroit, Lookout Point and Cougar. The drawdowns are typically to the lowest level possible given operational constraints (for example, outlet cavitation limits) or the lowest achievable pool. Section 2.2.1, Flow Measures, contains a more detailed explanations of all these actions.

The drawdowns can limit the effectiveness of other actions within Alternative 3A. The spring reservoir drawdown can inhibit refill of the reservoirs into the late winter and spring. Since the reservoirs do not fill more often, there is less available water to augment flows downstream during the summer and fall compared to the NAA. In addition, if the reservoir water surface elevation does not rise to the spillway crest, the dam is unable to discharge water through that outlet, constraining the temperature operations that require the spillway.

As compared to the NAA, Alternative 3A can have the effect of releasing water during the spring and lowering flows in the summer. This is more pronounced during drier years than in wetter years since a larger portion of the summer flow is stored water from the reservoirs. An average flow year would see Detroit and Cougar unable to contribute meaningfully to flow targets downstream.

NAA flow targets and the lower integrated temperature and habitat flow regime flow targets in Alternative 3A would not be met across the WRB during an average flow year. These notably lower flows would have long term consequences across the WRB. Effects from the Alternative 3A to hydrologic processes: Major.

*3.2.2.7.1 Santiam Subbasin*

Alternative 3A would meaningfully alter the use of Detroit Reservoir (Figure 3.2-105) for all years. The reservoir elevation would not reach the top of conservation storage in even the wettest years. Most years, Detroit Reservoir would not appreciably rise above the spring reservoir drawdown elevation (1375 ft) while releasing inflow until the next winter, in January on average. Although it is not shown in the figure (as the lines are non-exceedance percentiles), Detroit would reach minimum conservation elevation (1450 ft) once between April and October during the period-of-record run.

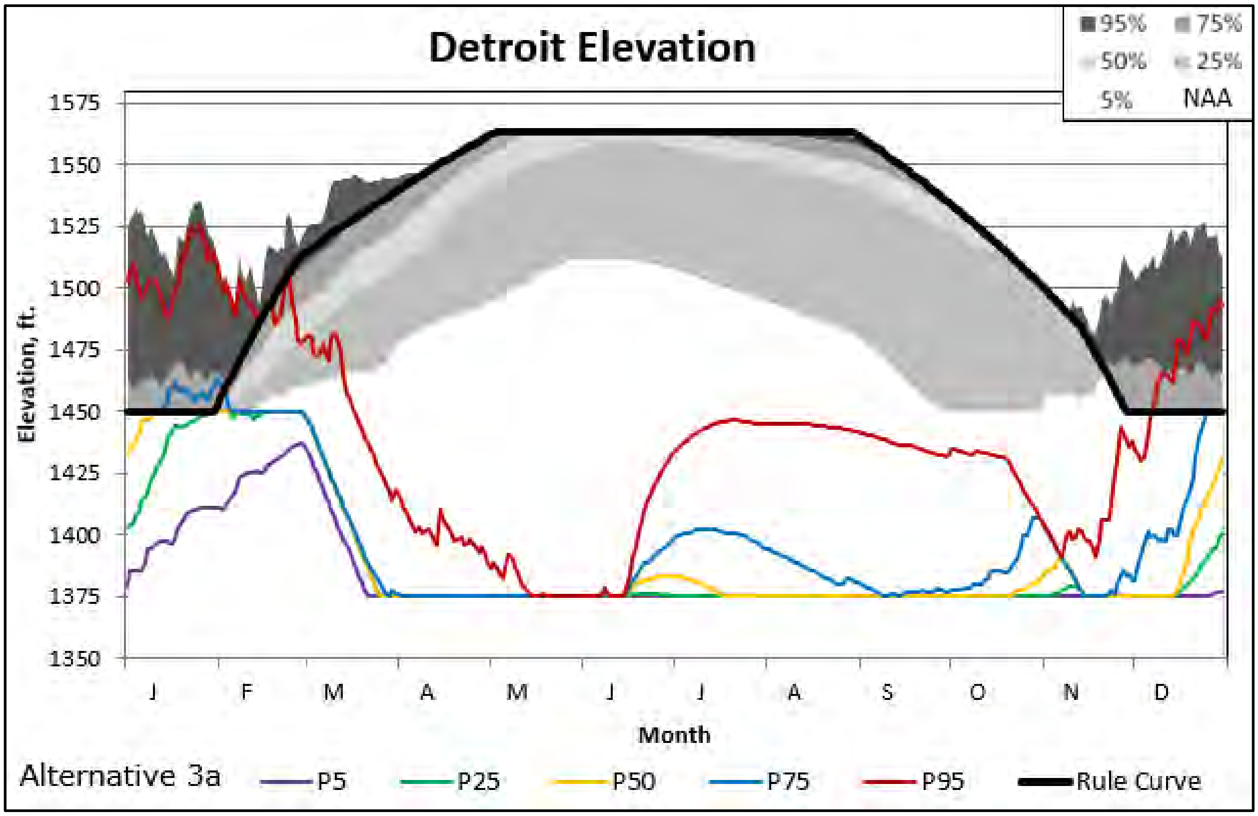



**Figure 3.2-105. Alternative 3A Detroit water surface elevation non-exceedance compared with NAA**

The reservoir would usually be lower across the winter season as well. Particularly wet winters would force the reservoir back to the NAA elevations, but this would happen late in January or early February. The drawdowns and low summer reservoir elevation would have a stark effect on the flow from Detroit Dam as compared to the NAA. The releases from Detroit would be much higher during the spring reservoir drawdown as the reservoir drafts to the minimum elevation of 1375 ft.

During the summer, passing inflow (Figure 3.2-106) would not be enough to maintain the minimum downstream integrated temperature and habitat flow regime target in about 75 percent of years. The average year (P50 line) would be below the target from mid-June to nearly November, with a typical flow of about 600 cfs (the minimum flow target is 1,050 cfs).

The driest years would not reach the minimum flow target from May through December, a much longer time than the NAA, reaching a minimum flow of about 400 cfs.

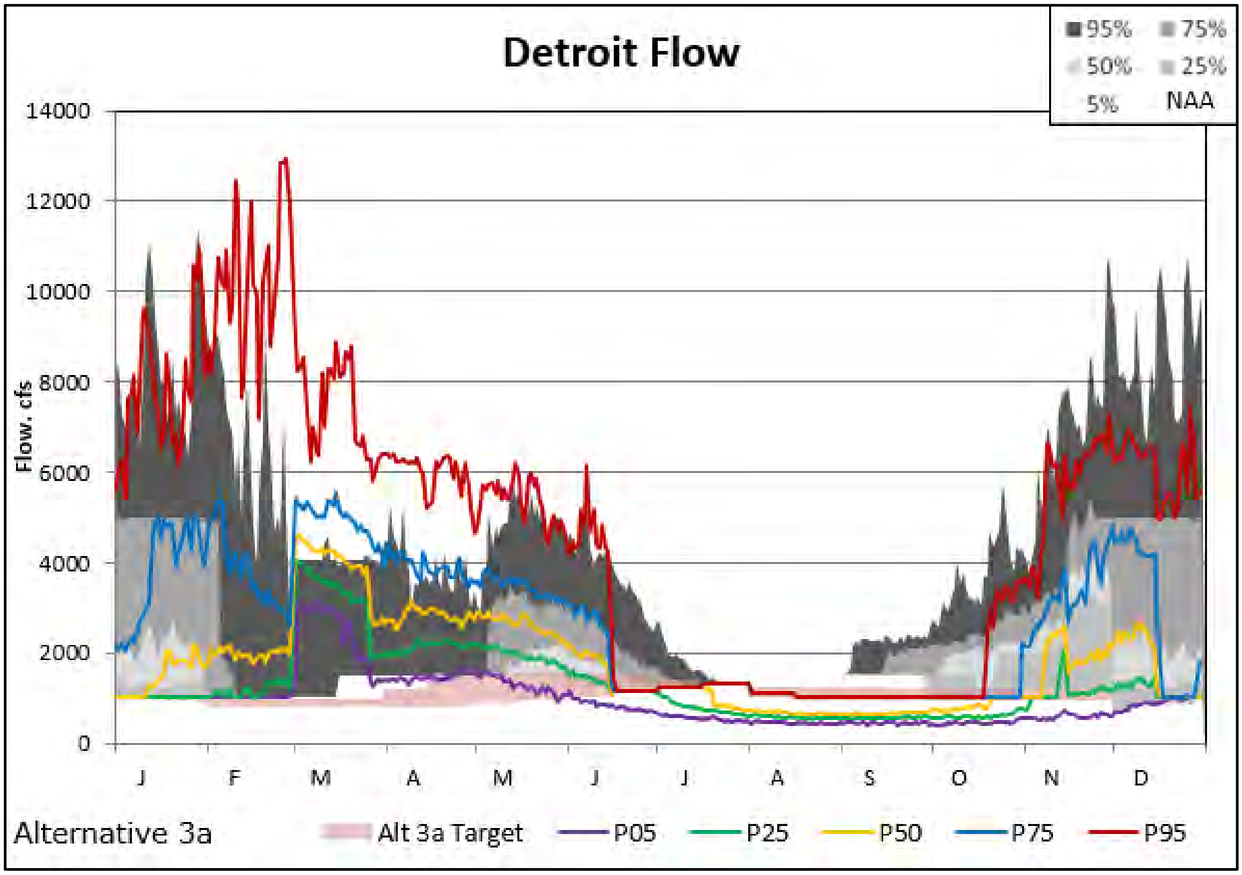



**Figure 3.2-106. Alternative 3A Detroit outflow non-exceedance compared with NAA**

Green Peter (Figure 3.2-107) would have a deeper fall reservoir drawdown but would not have a spring reservoir drawdown in Alternative 3A. The result would be much less impact to reservoir elevation during the rest of the year through the spring and summer. The reservoir would release its additional stored water earlier in the summer to meet the downstream flow targets and to compensate for the lack of water at Detroit, starting about one month earlier than the NAA across water years. The integrated temperature and habitat flow regime targets are lower than the NAA's BiOp targets downstream of Foster (Figure 3.2-108), so the driest years (P05) would peak at a higher elevation in Alternative 3A than in the NAA.

Although the target elevation of the deeper fall reservoir drawdown is 780 feet, Green Peter would be unable to draft that low in slightly more than half of years. This is due to inflow during wetter than typical years. As the reservoir elevation falls, the capacity of the outlets also falls – there is less pressure pushing the water out.

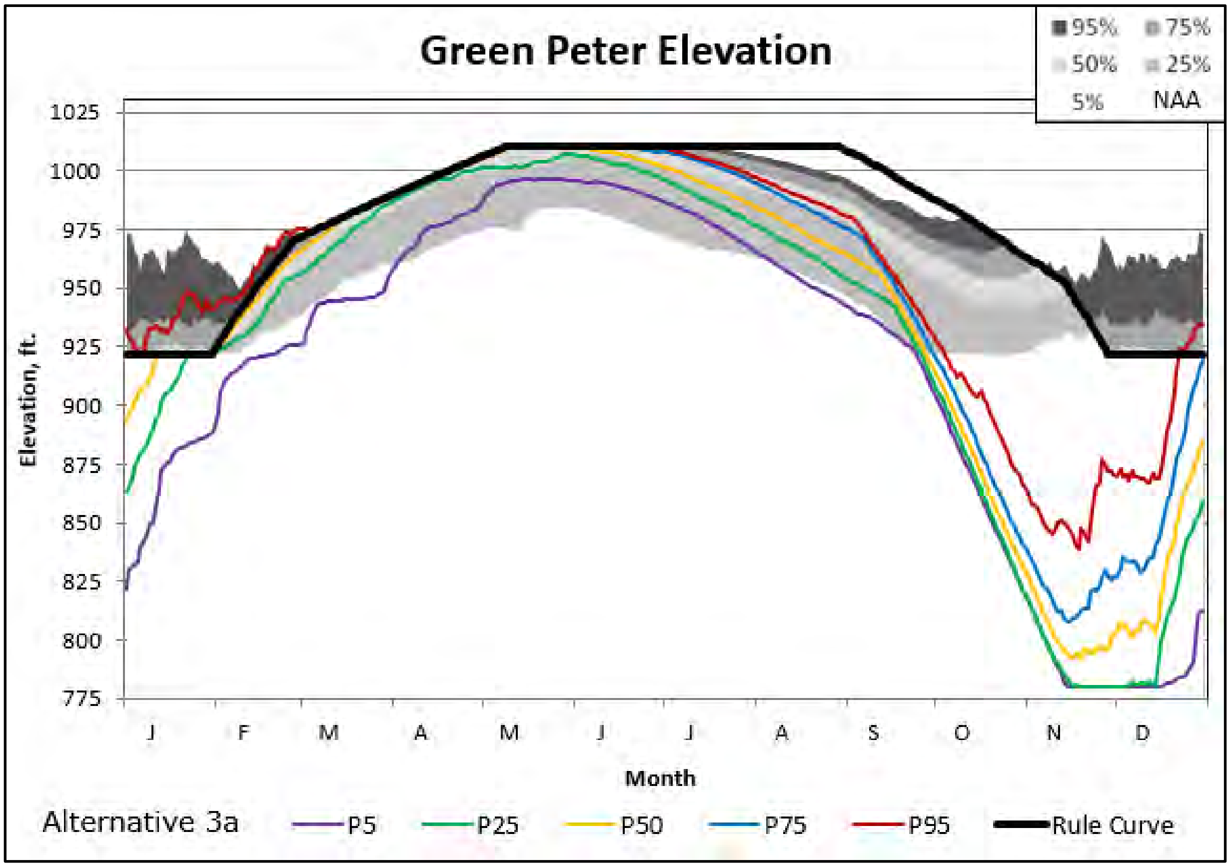



**Figure 3.2-107. Alternative 3A Green Peter water surface elevation non-exceedance compared with NAA**

Downstream of Foster, flow would be similar to the NAA during average to wet years except during the deeper fall reservoir drawdown period at Green Peter. The elevated flows would be a result of the release from Green Peter to reach the low reservoir elevation. The integrated temperature and habitat flow regime targets are met throughout the summer and fall. The dry years trace the bottom of the targets whereas most of the rest are at the top of the range or above it. Only in the driest Novembers, when Green Peter is already at its low elevation, the flow would fall below target for about two weeks.

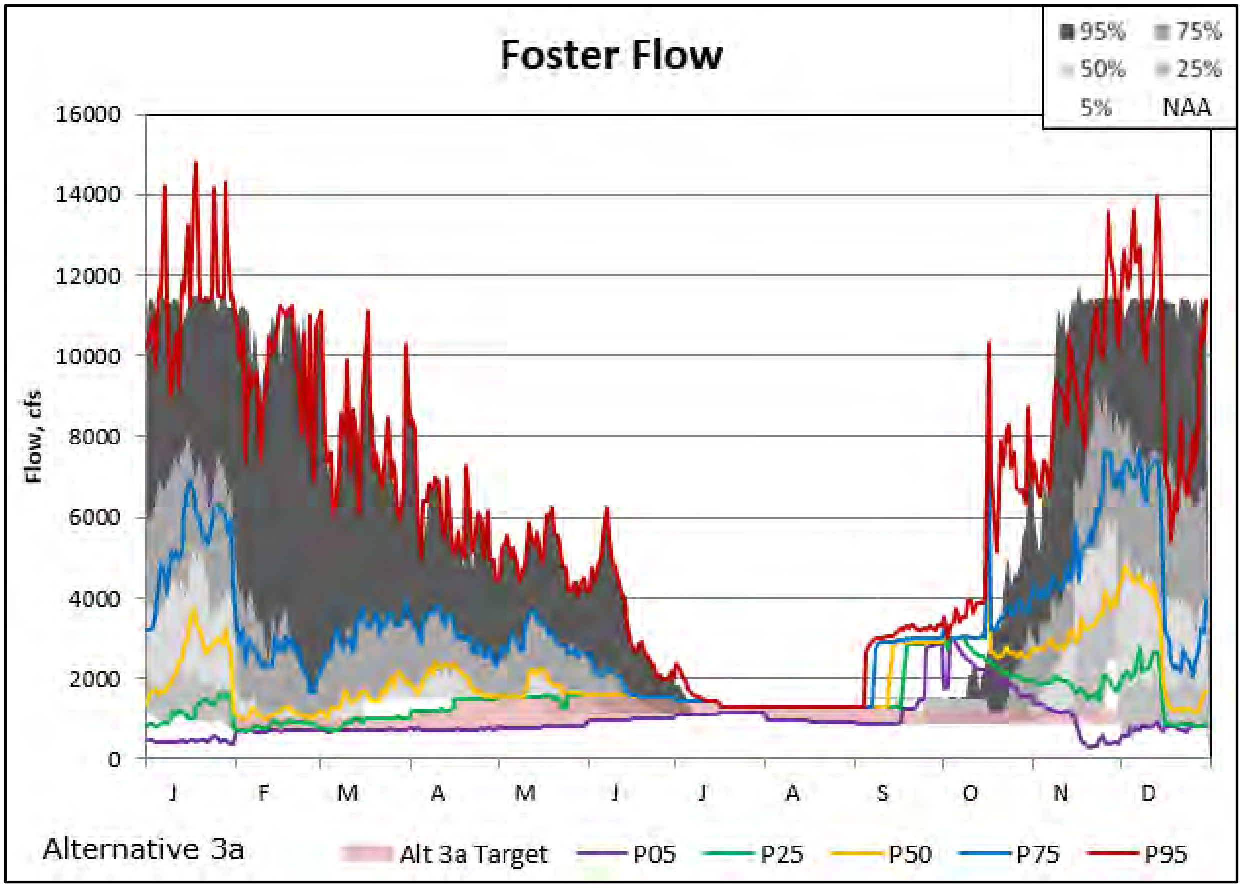



**Figure 3.2-108. Alternative 3A Foster flow non-exceedance compared with NAA**

The Santiam at Jefferson (Figure 3.2-109) would combine the changes at Detroit – in the North Santiam subbasin – and Green Peter – in the South Santiam subbasin. Higher flows would be evident when the reservoirs draft to the drawdowns (principally March and October) compared to the NAA. There would be a larger variation in flow in the summer, with more flow in the wettest years and less flow in the driest years compared to the NAA. There would be much less change in the seasonal flow pattern as compared to Alternatives 1 and 4, as the storage aspects of those alternatives would be constrained by the drawdowns.

Although there are many relatively minor differences, one of the largest differences between Alternatives 3A and 3B is the larger outflow from Detroit in preparation for the deeper fall reservoir drawdown in 3B, which is not required in 3A as the pool does not typically refill during the summer.

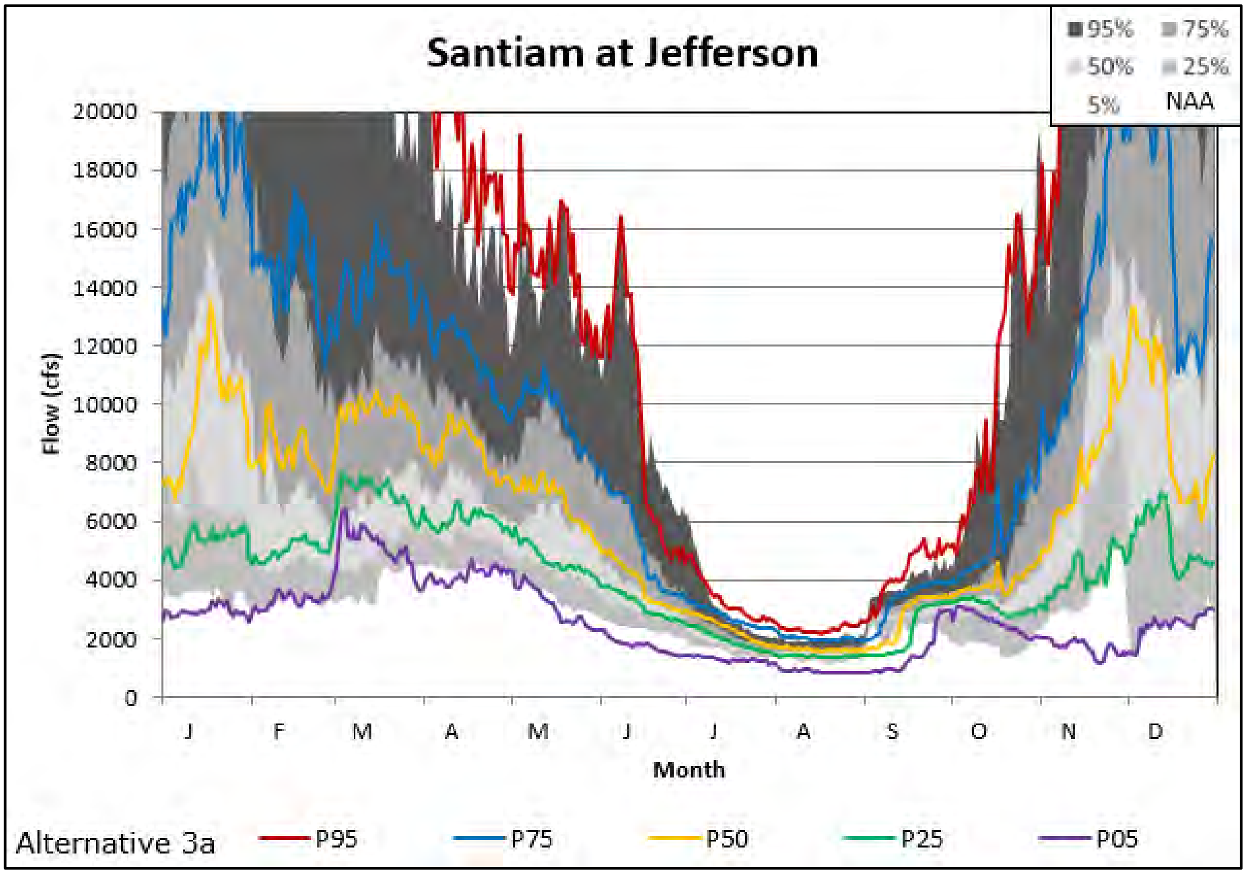



**Figure 3.2-109. Alternative 3A Santiam at Jefferson flow non-exceedance compared with NAA**

#### *3.2.2.7.2 Long Tom Subbasin*

As explained in the NAA, Fern Ridge reservoir (Figure 3.2-110) is operated for recreation and fish and wildlife habitat in the conservation season and typically seeks to maximize the reservoir pool during the summer. Since Fern Ridge has a large surface area and small volume compared to the other WVS reservoirs, there is limited scope to change its operation and the water surface elevations within Fern Ridge remain nearly the same as the NAA. Downstream flows at Monroe would remain similarly unchanged for Alternative 3A.

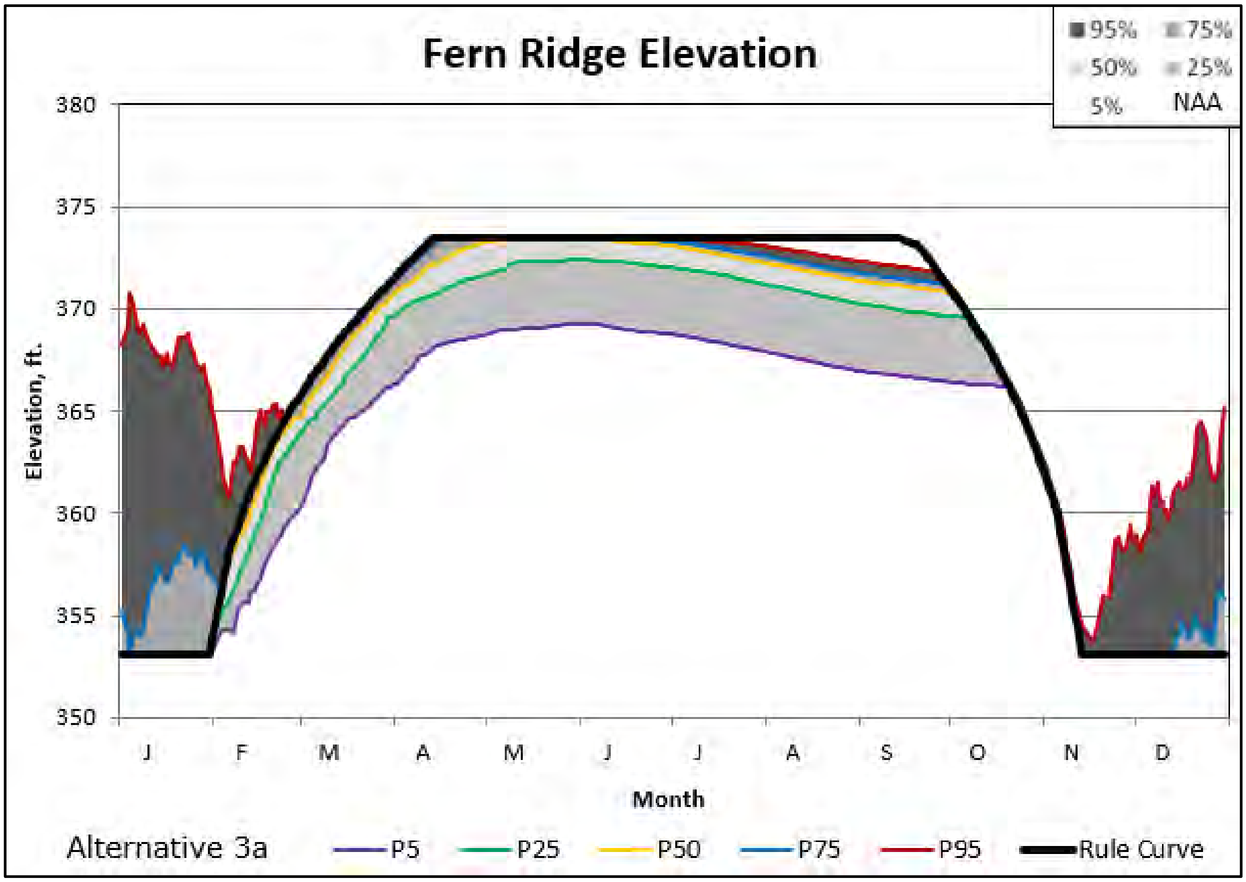



**Figure 3.2-110. Alternative 3A Fern Ridge water surface elevation non-exceedance compared with NAA**

### *3.2.2.7.3 McKenzie Subbasin*

Like Detroit reservoir in the Santiam Subbasin, Cougar reservoir (Figure 3.2-111) would have both a spring and fall reservoir drawdown. Since the spring reservoir drawdown lasts through the typical refill period, Cougar reservoir would only able to rise above the drawdown elevation (1517 feet) during the summer in wetter years, which does not occur under the NAA. The only time Cougar would be full under Alternative 3A would be a FRM operation of a particularly rare and large storm in the winter months. Cougar would only be able to meet its minimum downstream flow target of 300 cfs for the entire summer about 25 percent of the time compared to the NAA. An average year, where the P50 line is at minimum reservoir elevation, would miss this target from August to October.

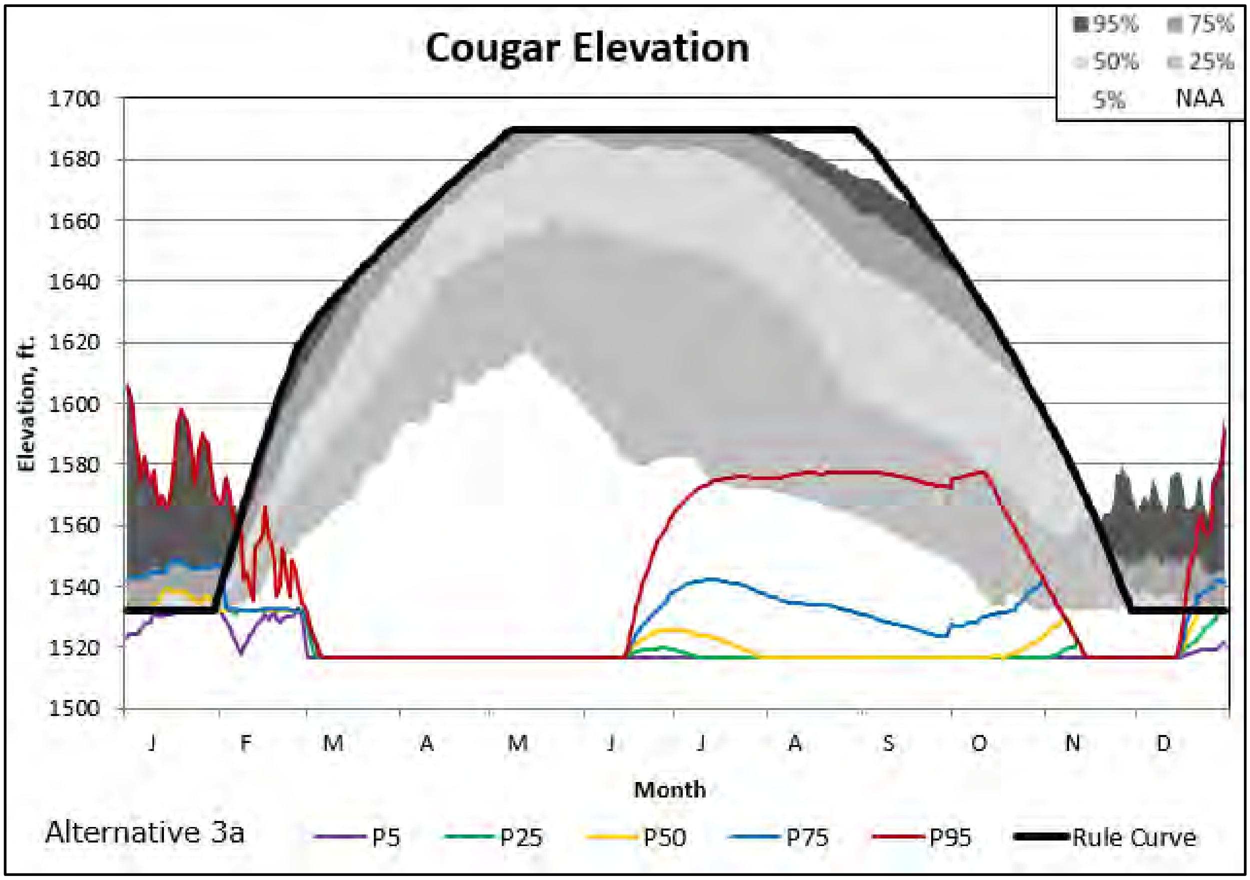



**Figure 3.2-111. Alternative 3A Cougar water surface elevation non-exceedance compared with NAA**

Blue River (Figure 3.2-112) would have a deeper fall reservoir drawdown 15 feet below its minimum conservation pool. The spring refill would reach the maximum conservation elevation more often at Blue River than in the NAA – see the P25 line in the figure – due to the lower integrated temperature and habitat flow regime targets. The reservoir would draft earlier in the summer to augment some of the flow not available at Cougar.

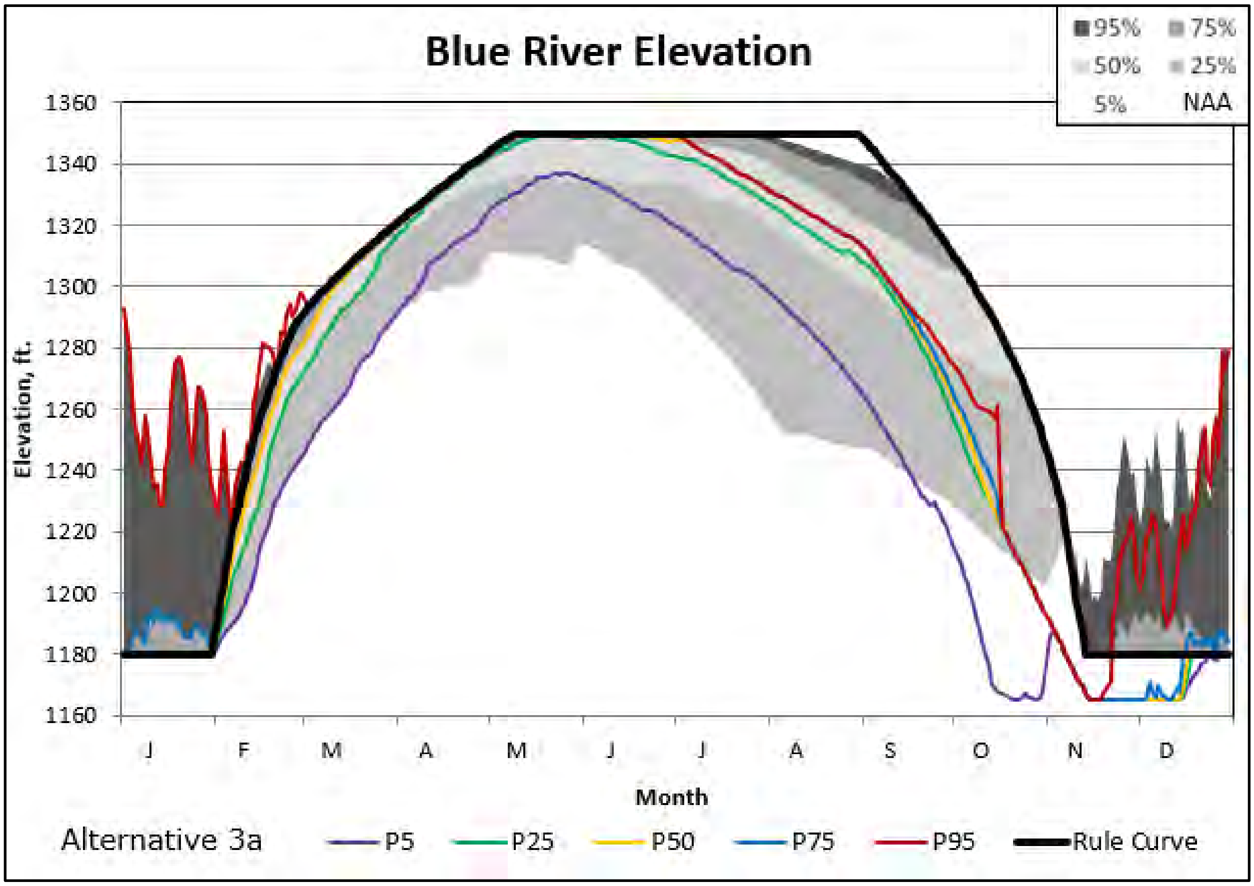



**Figure 3.2-112. Alternative 3A Blue River water surface elevation non-exceedance compared with NAA**

The downstream control point, McKenzie River at Vida (Figure 3.2-113), would show the combined effect of more and less available conservation storage at Blue River and Cougar, respectively. The higher flows during the spring of wet years result from Cougar not filling during conservation season as it does in the NAA. The lower flows during the driest years of April to June are due to Blue River filling more while meeting the lower downstream flow targets. During the summer, Alternative 3A flows would be marginally below the NAA, as the increased storage at Blue River and no storage at Cougar nearly balance out – Blue River is smaller than Cougar, so flows would be a bit lower across the summer.

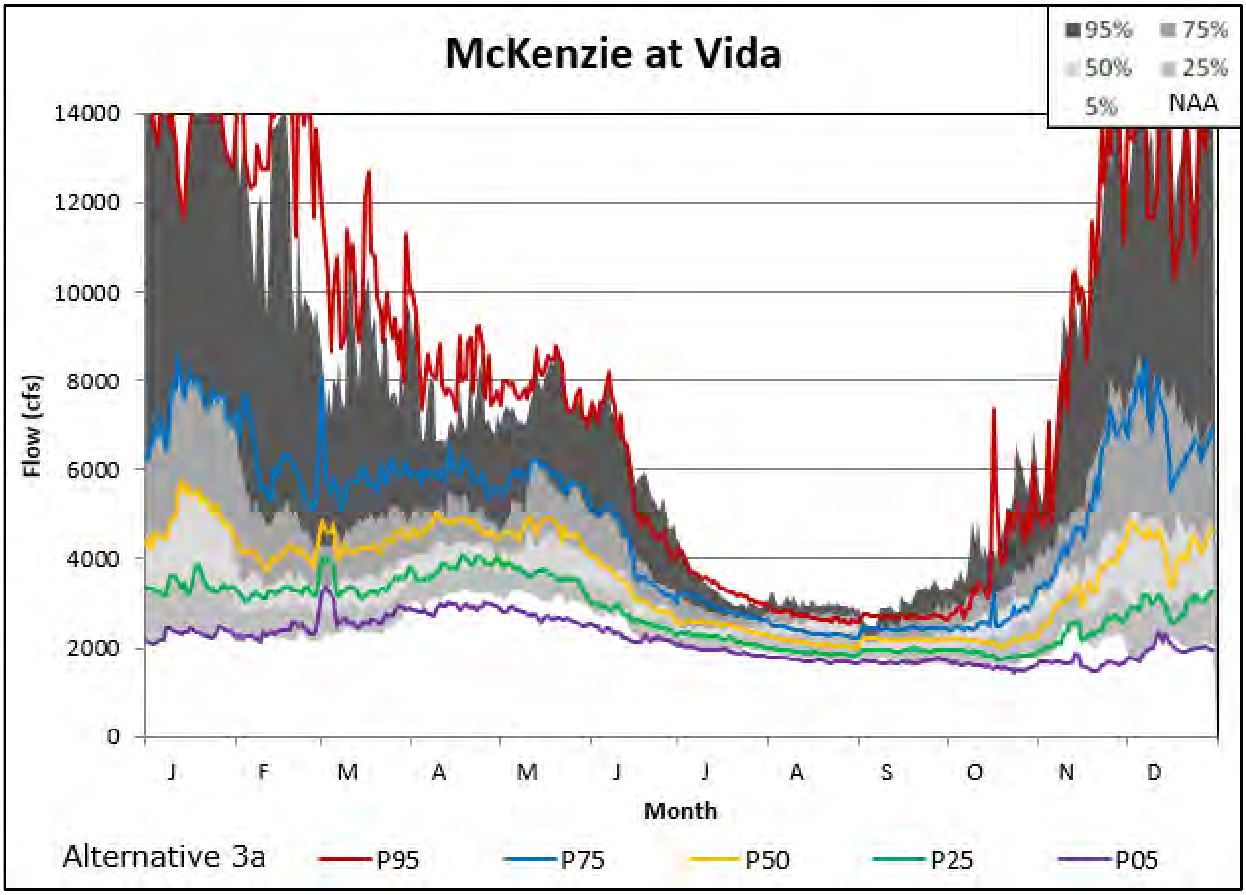



**Figure 3.2-113. Alternative 3A McKenzie River at Vida flow non-exceedance compared with NAA**

### *3.2.2.7.4 Middle Fork of the Willamette Subbasin*

Hills Creek, Lookout Point and Fall Creek would all have deeper fall reservoir drawdowns in Alternative 3A (Fall Creek's is an existing operation in the NAA) and Lookout Point would also have a spring reservoir drawdown. During spring conservation storage season, Hills Creek (Figure 3.2-114) would fill more frequently and achieve a higher elevation during dry years compared to the NAA. The reservoir would then be drafted to meet downstream flow targets, which flows through Lookout Point (Figure 3.2-115). Hills Creek's stored water would be exhausted in mid-September in an average year (P50 line) and most years – between the P25 to P75 lines – would fall within two weeks of average.

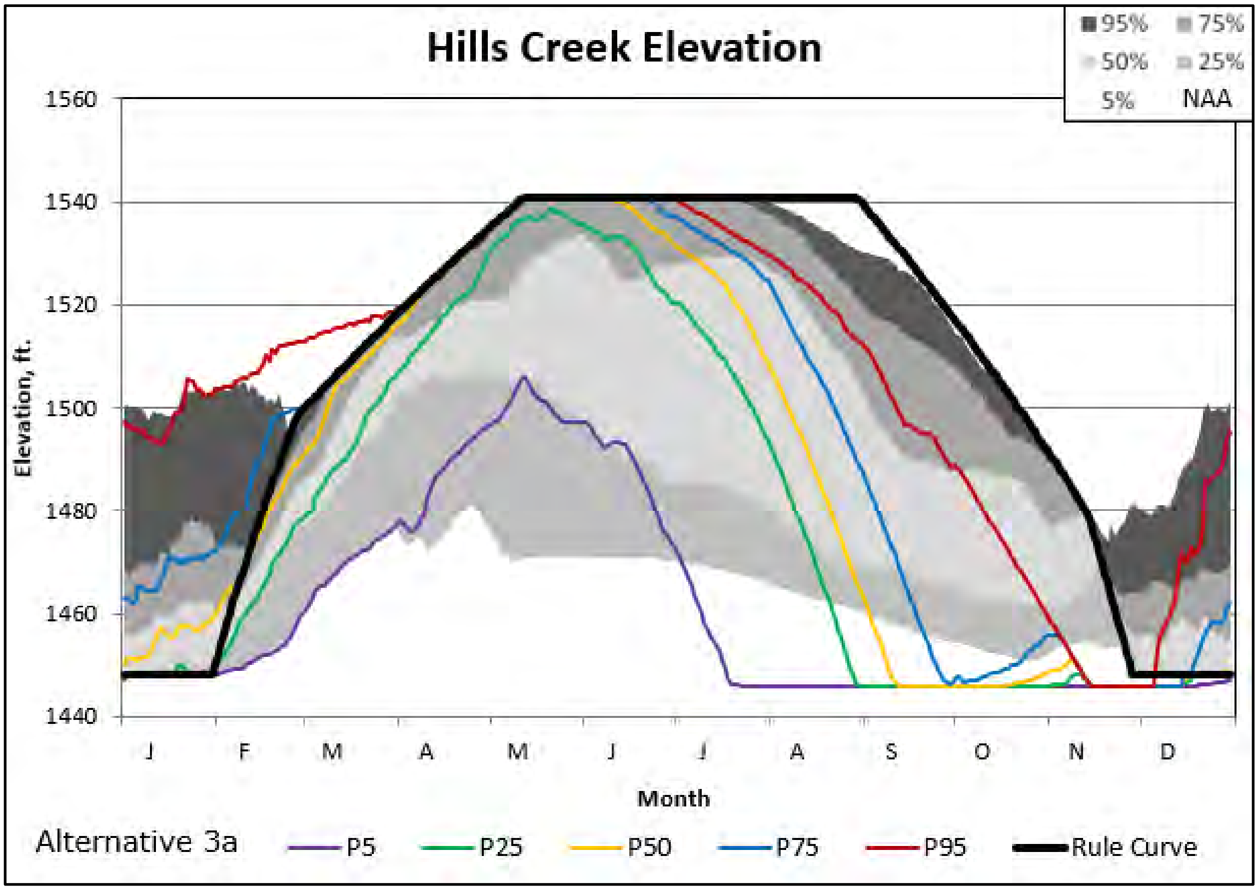



**Figure 3.2-114. Alternative 3A Hills Creek water surface elevation non-exceedance compared with NAA**

Despite having a spring reservoir drawdown like Detroit in the Santiam Subbasin and Cougar in the McKenzie Subbasin, Lookout Point would be able to fill up to minimum conservation elevation in most years (P75 line), meaning there is minor change from the NAA. The reservoir rises from its minimum spring reservoir drawdown elevation in the driest years (P05) but returns to the minimum in about two months. This is due to the stored water from Hills Creek upstream. Neither Detroit nor Cougar has the benefit of being able to refill from water stored in an upstream reservoir.

It should be noted that Lookout Point would not achieve its spring and fall reservoir drawdown target of 761 feet in about 50 and 25 percent of years, respectively. Higher inflows during the drawdowns, inflows from Hills Creek during the spring, and reduced outlet capacity from the lower reservoir elevation – there is less pressure pushing the water out – means that Lookout Point would remain above the target elevation for the duration of the drawdown periods.

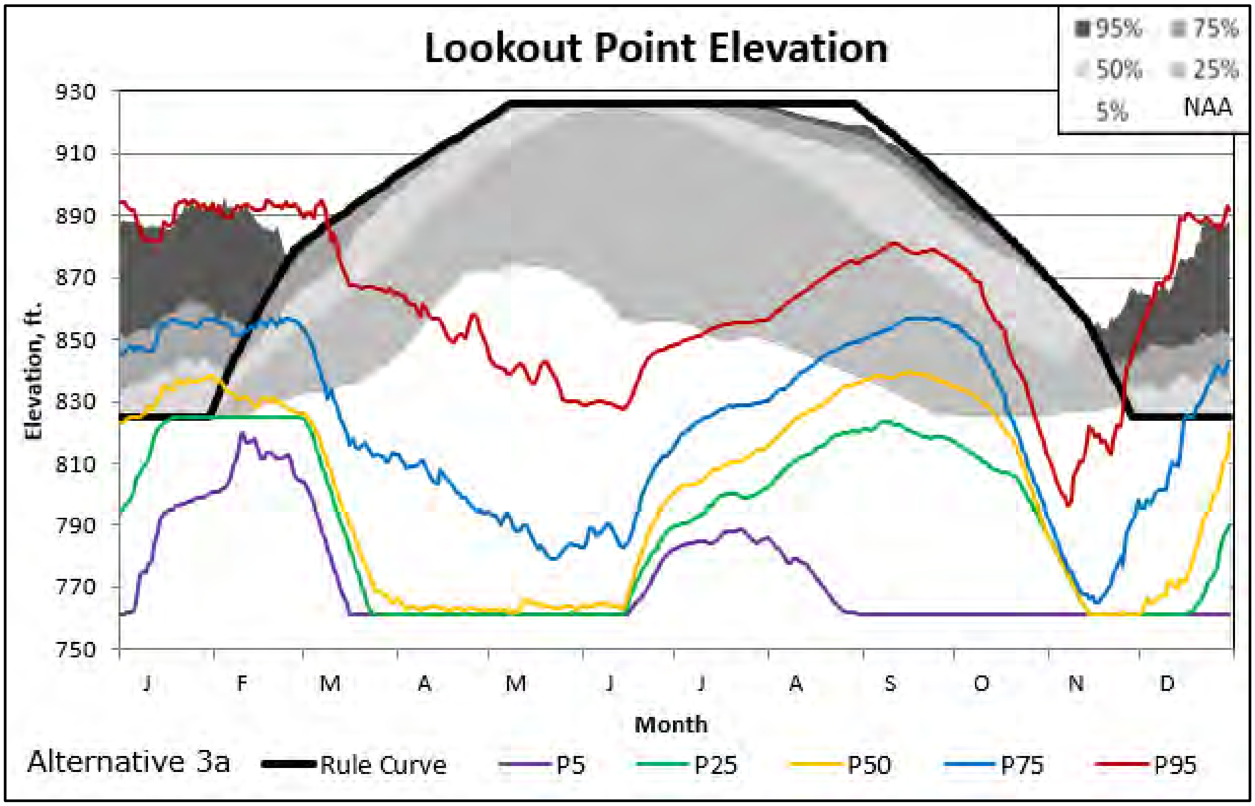



**Figure 3.2-115. Alternative 3A Lookout Point water surface elevation non-exceedance compared with NAA**

Fall Creek (Figure 3.2-116) water surface elevations and outflows would be very similar to the NAA, which already implements a fall drawdown to the same elevation as in Alternative 3A.

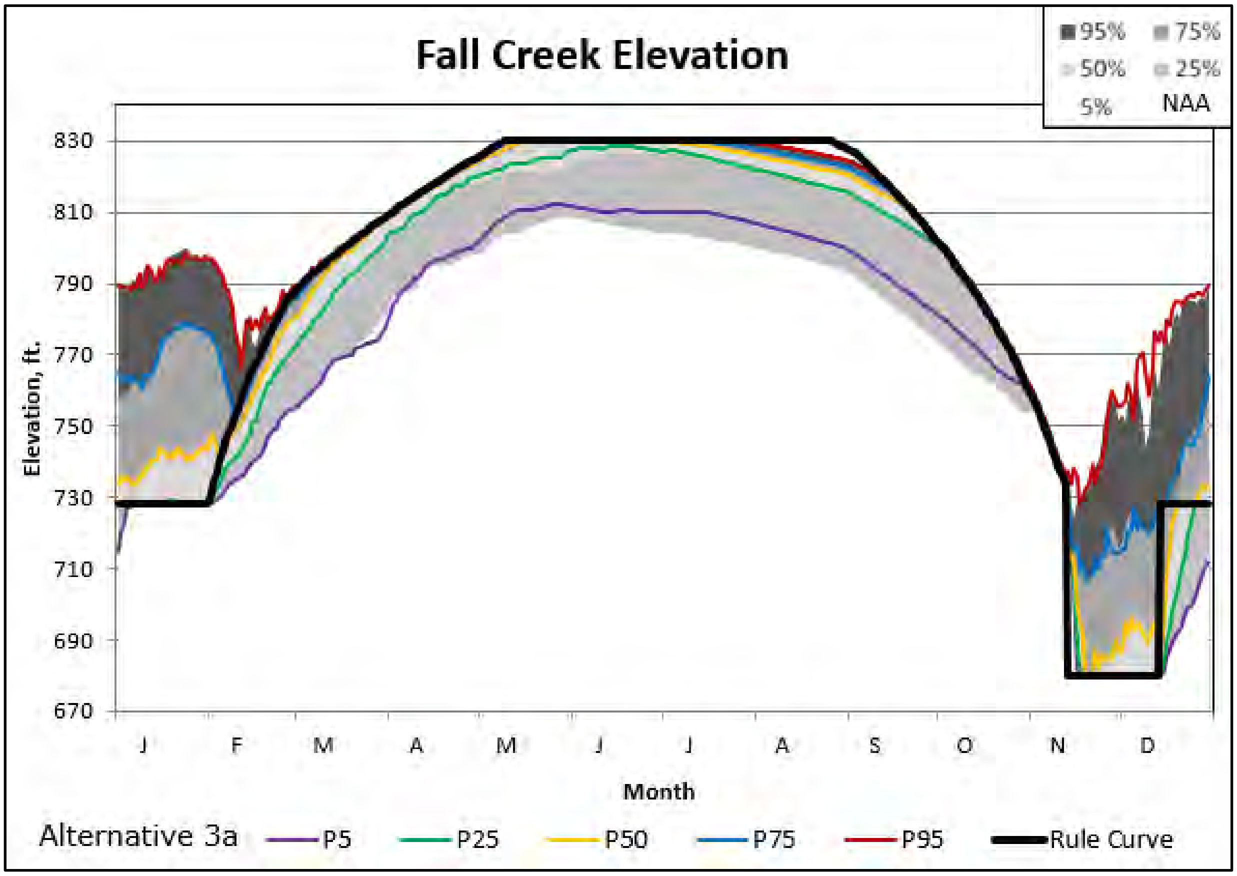



**Figure 3.2-116. Alternative 3A Fall Creek water surface elevation non-exceedance compared with NAA**

The control point for the Middle Fork subbasin WVS dams at Jasper (Figure 3.2-117) would show the changed flow from the drawdowns and limited augmented flow during the summer. Flow at Jasper would be higher across all years from March until May. As summer starts, flow would be drastically reduced as compared to the NAA as the reservoirs attempt to refill with available inflow. From June until September typical wet-year flows would be comparable to driest years in the NAA. The driest years in Alternative 3A would not return to the NAA baseline until late October. Although Lookout Point and Fall Creek are above their minimum elevations during this time, this would represent the WVS attempt to meter out water throughout the summer, preventing even lower flows in the river.

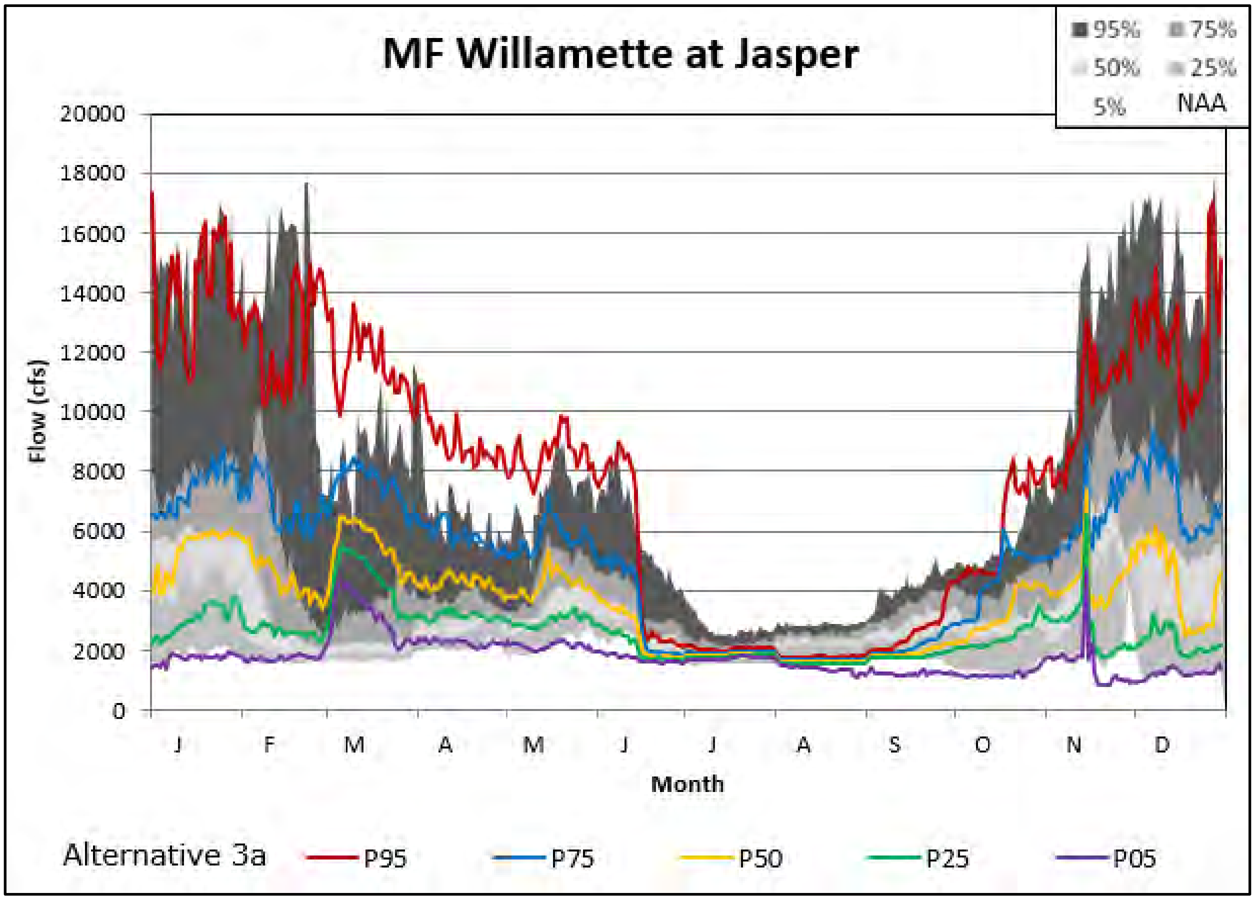



**Figure 3.2-117. Alternative 3A Middle Fork of the Willamette at Jasper flow non-exceedance compared with NAA**

### *3.2.2.7.5 Coast Fork of the Willamette Subbasin*

Dorena and Cottage Grove reservoir elevations behave very similarly in Alternative 3A, as shown in Figures 3.2-118 and 3.2-119, respectively. The refill to slightly higher levels than the NAA due to the lower integrated temperature and habitat flow regime targets downstream. Reservoir storage would be similar for average and wet years throughout the summer and fall. They would draft faster from higher initial water surface elevations in dry years as these reservoirs make up for the lower storage elsewhere in the system. In especially dry falls, the reservoirs would augment instream flows by using the inactive pools, though the lower water surface elevations would be activated a bit less often in Alternative 3A as opposed to Alternative 3B.

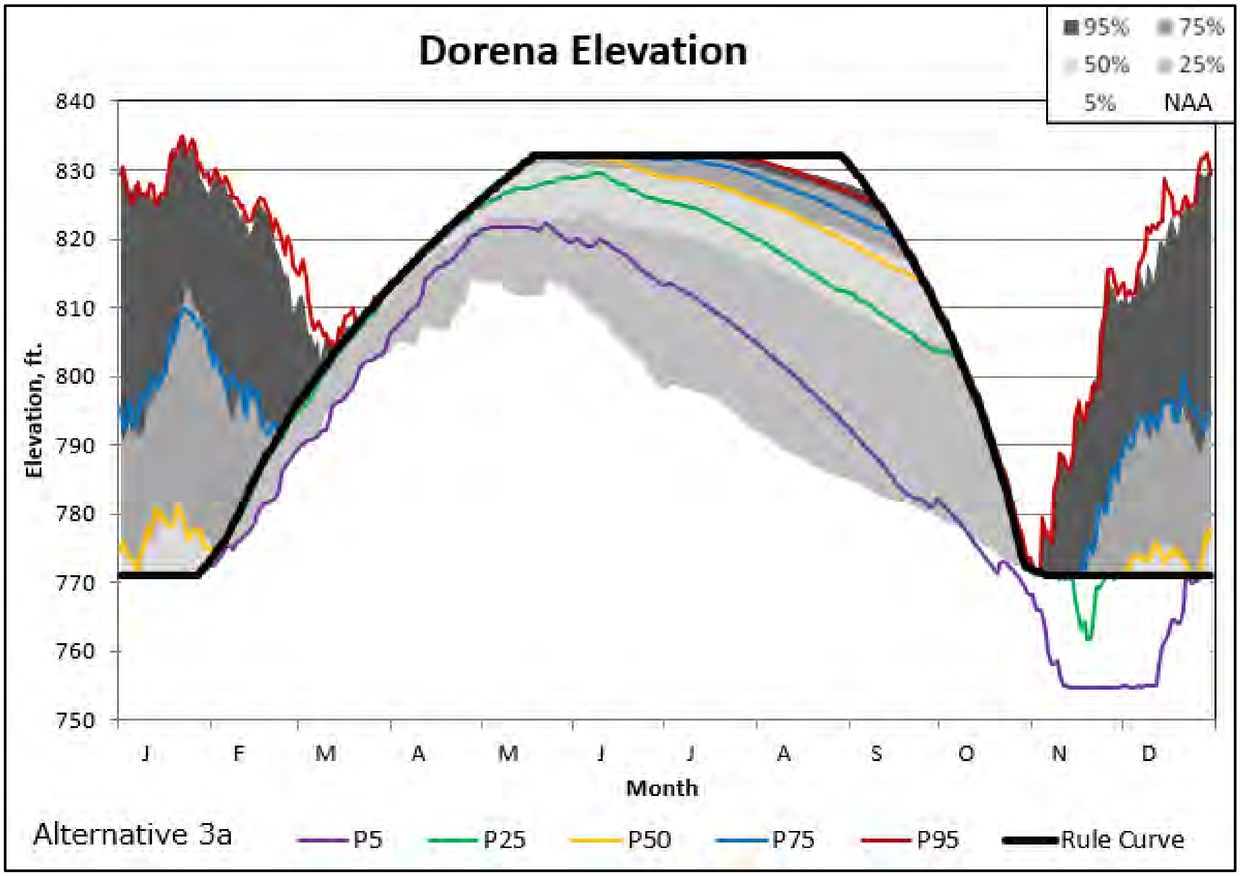



**Figure 3.2-118. Alternative 3A Dorena water surface elevation non-exceedance compared with NAA**

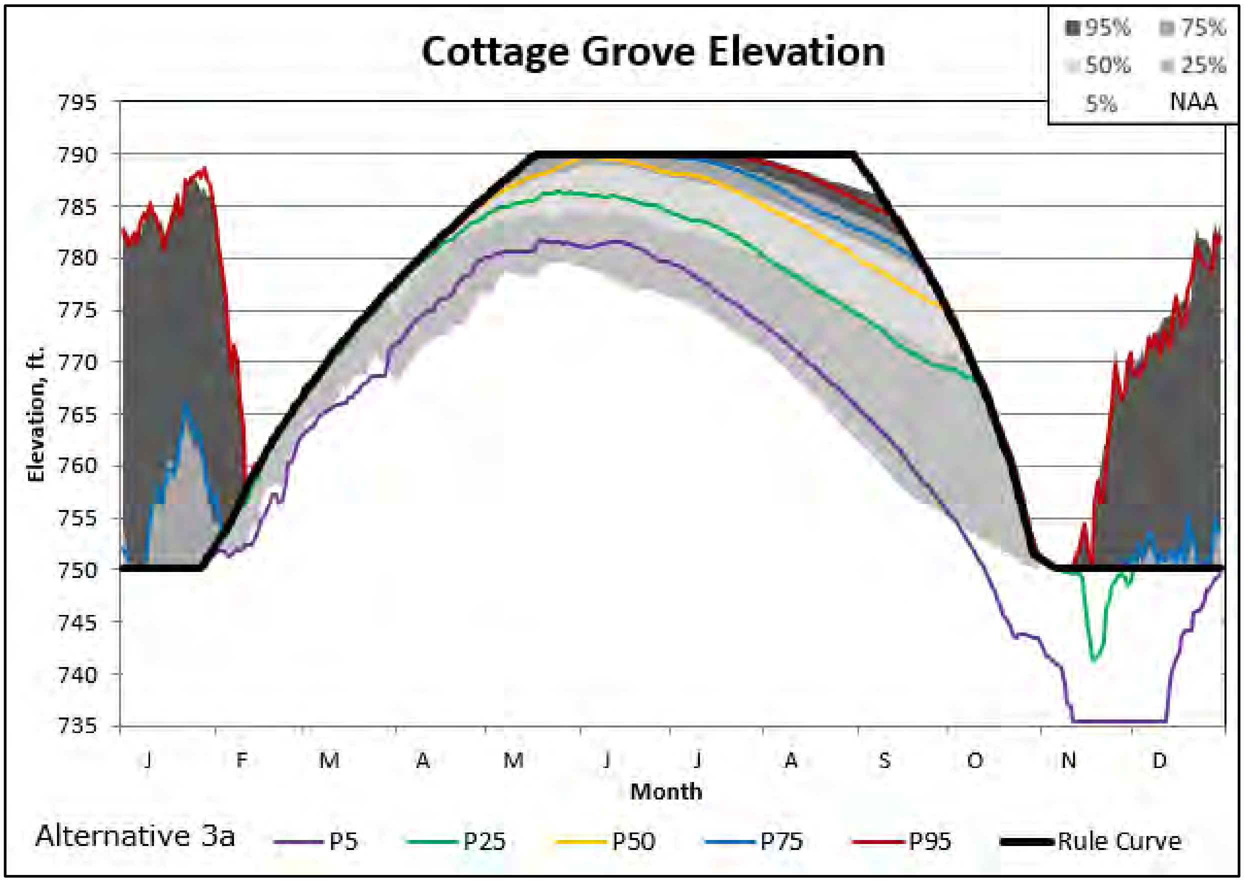



**Figure 3.2-119. Alternative 3A Cottage Grove water surface elevation non-exceedance compared with NAA**

The flow at Coast Fork of the Willamette River at Goshen (Figure 3.2-120) would be most different from the NAA in dry years. The additional stored water accumulated in Dorena and Cottage Grove is evident by the decreased flow from April to June and increased flow July to October as the reservoir released that water. Although there are minor differences, Alternative 3A and 3B are similar at Goshen from a hydrologic perspective.

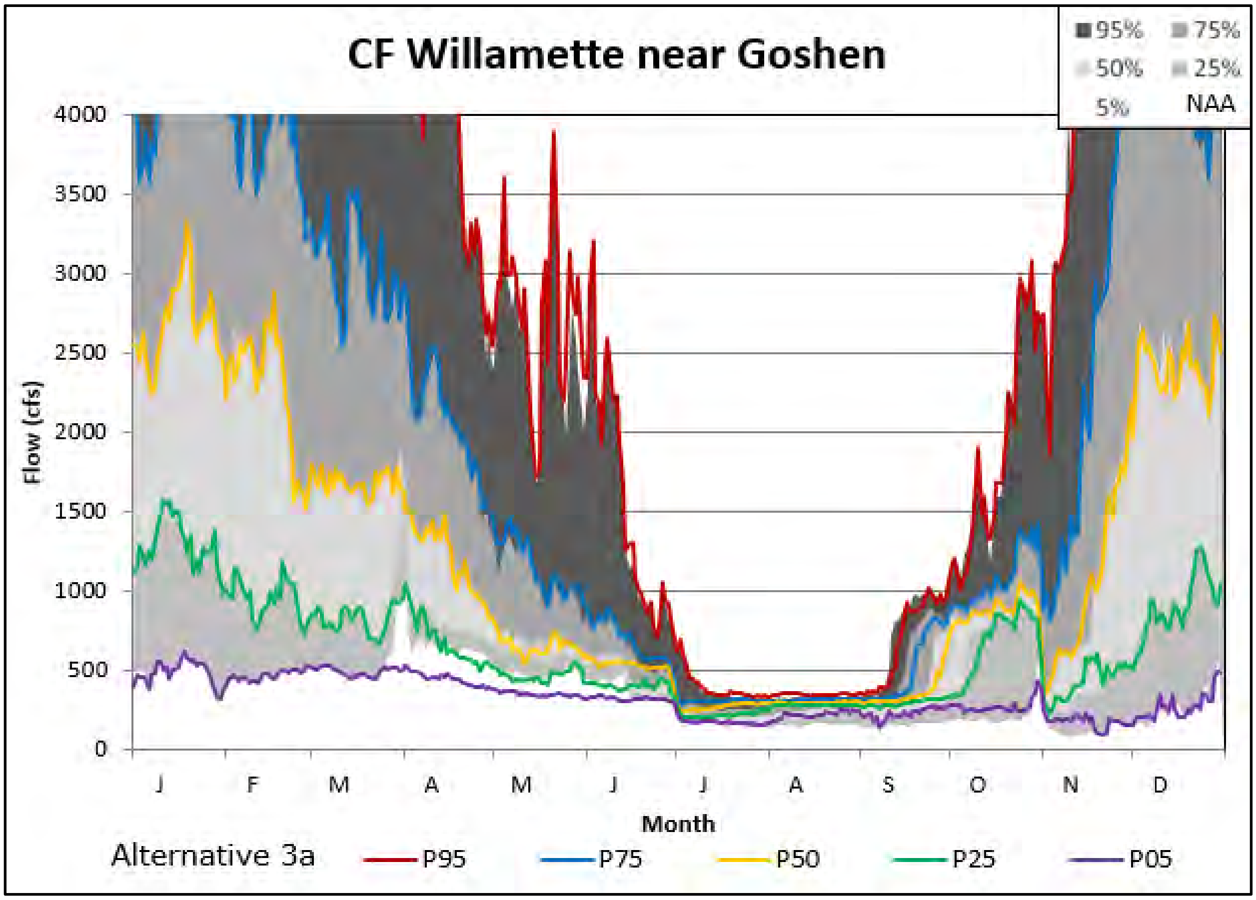



**Figure 3.2-120. Alternative 3A Coast Fork of the Willamette at Goshen flow non-exceedance compared with NAA**

### *3.2.2.7.6 Mainstem Willamette River*

The Alternative 3A flow targets on the mainstem Willamette River at Albany and Salem (Figures 3.2-121 and 3.2-122, respectively) are the integrated temperature and habitat flow regime, which is lower than the BiOp targets in the NAA and add flows to the target at Salem during warm weather (the target box in the figure). Section 2.2.1, Flow Measures, contains a more detailed explanation of these flow targets.

In wet years, Alternative 3A would have consistently higher flow during the springtime at both Albany and Salem as compared to the NAA as storage reservoirs are being held lower for spring reservoir drawdown fish passage operations. The driest years would have lower flow in the spring due to the lower flow target at Salem.

After the end of the WVS spring reservoir drawdowns, flows would drop steeply across all years. The lower amount of total system storage means that the system cannot meet the flow target at Albany for at least one month more than 75 percent of years (P75 line). Flows at Salem would more consistently meet the integrated temperature and habitat flow regime target due the contributions from Green Peter, which does not have a spring reservoir drawdown for Alternative 3A. Even so, summer and fall flows would be comparable or lower across similar years in the mainstem Willamette River for Alternative 3A as compared to the NAA.

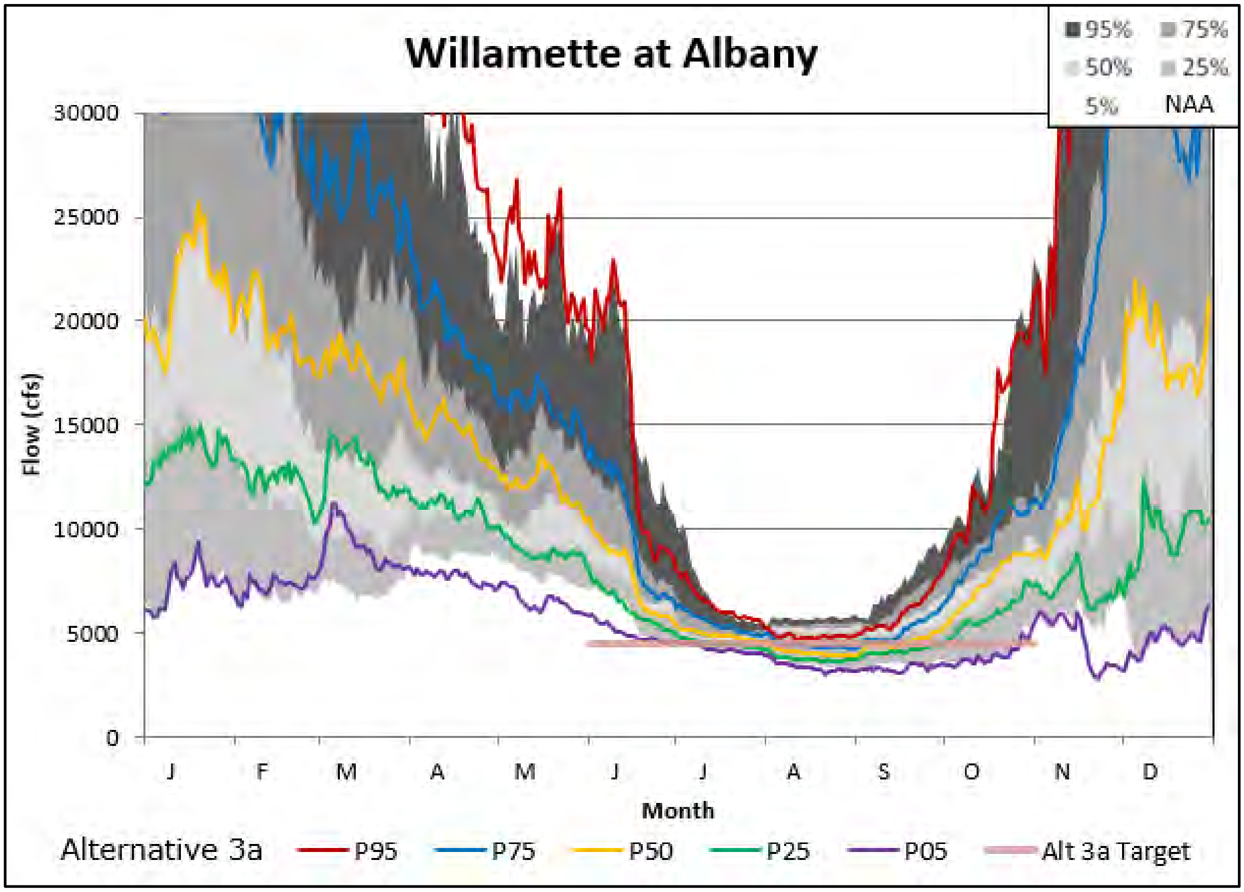



**Figure 3.2-121. Alternative 3A Willamette River at Albany flow non-exceedance compared with NAA**

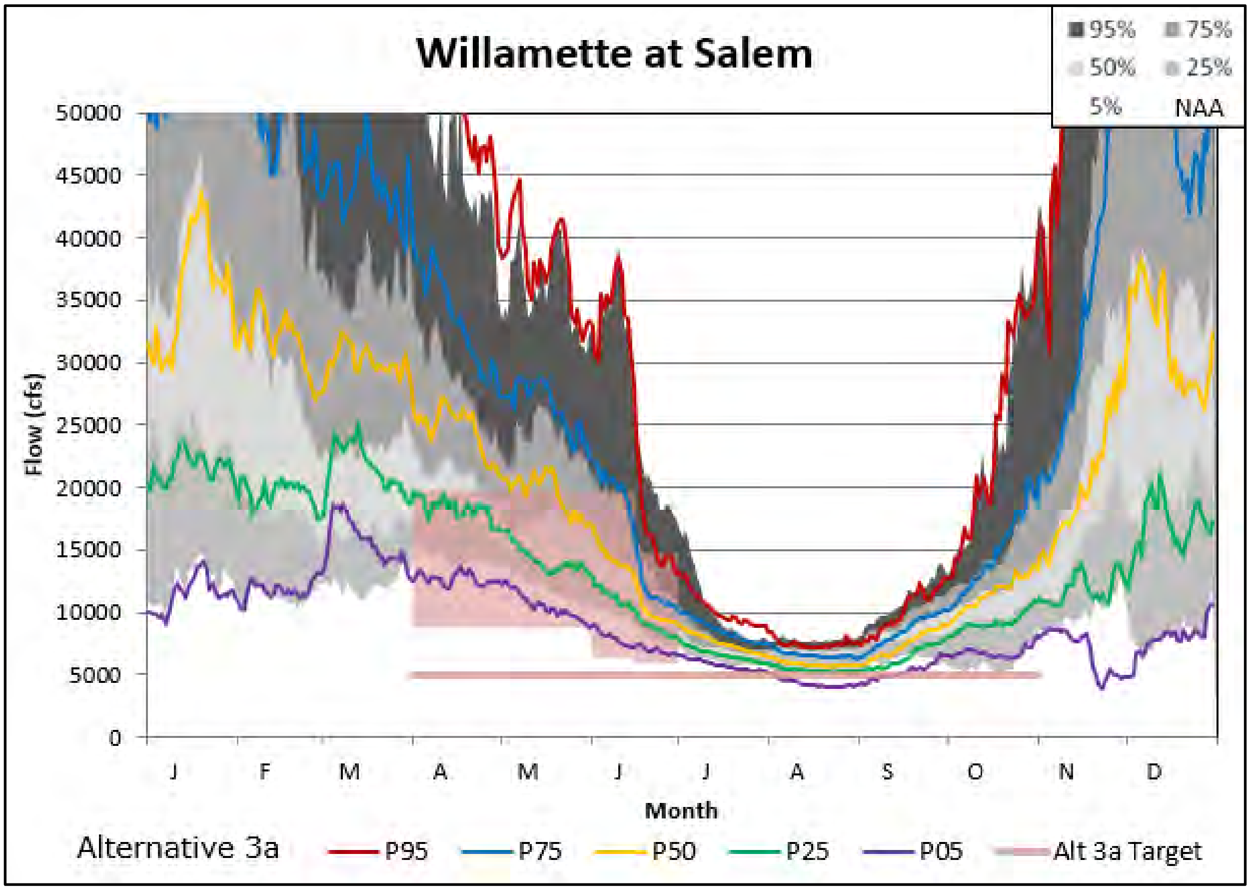



**Figure 3.2-122. Alternative 3A Willamette River at Salem flow non-exceedance compared with NAA**

*3.2.2.7.7 Near-Term Operations Measure*

See Alternative 2A, Section 3.2.2.4.7, for description of effects due to the Near-Term Operations Measure.

*3.2.2.7.8 Climate Change*

Climate change hydrologic factors such as seasonal flow volume shifts may stress the WVS under Alternative 3A operations compared to the NAA. Specifically, future increases in median wintertime flow volumes and average deceases in summertime baseflows will exacerbate effects already present in Alternative 3A. Climate change effects, and potential implications as discussed below, draw on the climate change projection and trend information provided in the climate change appendices.

Lower reservoir pool elevations and flow releases for downstream flow targets are likely in the future. In addition, spring inflow quantity and timing is projected to be more variable in the future as climate change trends take hold. Limited to no snowpack is a consequence of projected warming in the Valley and conversion of snow to wintertime flows. The projection for even drier, warmer, and earlier arriving summers means that the spring reservoir drawdowns leave the reservoirs even lower than the baseline Alternative 3A. Since the spring reservoir drawdowns last past April, when inflows would start to decline precipitously, Detroit and Cougar could struggle to store water for release later in the year. Lookout Point would be able to store some of the water released from Hills Creek, but it is likely to fill much less often compared to the NAA.

Alternative 3A does not currently meet its August downstream flow targets at Albany about 75 percent of the time which does not occur under the NAA. Decreasing summer flow projections indicate that Alternative 3A would rarely, if ever, meet the Albany flow target. Salem would be less notably affected due to flow augmentation from Green Peter, but the flow target would be missed more often, and dry years even drier. After the deeper fall reservoir drawdowns, there is additional storage space between the minimum drawdown elevation and the maximum flood storage elevation. It will typically take until middle of January (though timing varies throughout the WVS) for reservoirs to return to their current rule curve elevation. Downstream winter flows could be kept similar to the baseline with this additional storage capacity, despite projected increased winter peak flow and volume.

#### *3.2.2.8 Alternative 3B – Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

As the name implies, Alternative 3B would primarily use WVS dam operations for fish passage within the WRB – with a different mix of operations as compared to Alternative 3A – and not use structural modifications as in Alternative 4. An important part of this is the increased use of different flow outlets from the dams to control temperature, with the spillway supplying warmer water from the upper reservoir and the deeper outlets – ROs and turbines – supplying cooler water which does not occur under the NAA. Although these different outlet flows are calculated in the regulation model, they are not generally going to show up in the standard charts presented here, since the charts compare total flow with the NAA. The effects of those flow changes will show up in the temperature and biological modeling as inputs – both in temperature and TDG see Section 3.5.

Alternative 3B would also allow reservoirs augment instream flows by using the inactive or power pools, drafting below the NAA rule curves to meet minimum flow requirements. This would most frequently occur during the fall of drier years at reservoirs that do not have a deeper fall reservoir drawdown operation.

The primary set of flow targets are the “Integrated Temperature and Habitat Flow Regime,” which replace the 2008 NMFS BiOp in the NAA and Congressionally authorized minimum flows in Alternative 1. The integrated temperature and habitat flow regime targets are generally higher and more variable the Congressionally authorized minimum flows. Briefly, the integrated temperature and habitat flow regime has two sets of bi-weekly targets at a WVS reservoir, each set for whether the reservoir is higher or lower than 90 percent of rule curve elevation. Flows are reduced within a range down to minimums needed for fish survival when reservoirs are under the 90 percent threshold. However, these are adaptive within a water year and can return to return to levels higher than the NAA 2008 BiOp flows downstream of the dams if reservoir levels increase.

Alternative 3B would implement spring and fall reservoir drawdowns at some WVS reservoirs for volitional downstream fish passage. The spring reservoir drawdown operations are at Hills Creek, Green Peter and Cougar (to the diversion tunnel) and the deeper fall reservoir drawdown operations are at Blue River, Hills Creek, Green Peter, Detroit, Lookout Point and Cougar which would not occur under the NAA. The drawdowns are typically to lowest level possible given operational constraints (for example, outlet cavitation limits) or the lowest achievable pool. Both the spring and fall reservoir drawdowns at Cougar make use of the diversion tunnel instead of the RO and turbines. This leads to a much lower drawdown to 1330 feet, instead of 1517 feet as in Alternative 3A. Section 2.2.3, Downstream Fish Passage Measures, contains a more detailed explanations of all these actions.

The drawdowns can limit the effectiveness of other actions within Alternative 3A. The spring reservoir drawdown can inhibit refill of the reservoirs into the late winter and spring. Since the reservoirs do not fill more often, there is less available water to augment flows downstream during the summer and fall. In addition, if the reservoir water surface elevation does not rise to the spillway crest, the dam is unable to discharge water through that outlet, constraining the temperature operations that require the spillway.

Summer flow would be well below the NAA and the adaptability of the WVS would be constrained by a reduced ability to refill during conservation season. All changes to the WRB hydrology would be long term. Effects from the Alternative 3B to hydrologic processes: Major as compared to the NAA.

##### *3.2.2.8.1 Santiam Subbasin*

Detroit Reservoir (Figure 3.2-123) would fill more often during conservation use season and achieve a higher elevation when not full in Alternative 3B as compared to the NAA. Since Detroit does not have a spring reservoir drawdown as in Alternative 3A, Detroit meets its downstream flow targets (Figure 3.2-124) much more consistently throughout the summer. Only the driest years (P05 line) would be at the minimum flow target, with even the P25 line able to hit the upper bound of the target in the summer. The steep draft of the reservoir, though still within ramping rate regulations, to meet the deeper fall reservoir drawdown would require a period of bankfull outflows during October which does not occur under the NAA. WVS operations typically would change more slowly than the maximum allowable, so the flow would probably be spread out over a longer period if possible. Even so, Detroit would not always achieve the deeper fall reservoir drawdown target elevation of 1375 feet. Early fall rain would sometimes fill the reservoir with reduced outlet capacity, hindering its ability to reach the drawdown target elevation.

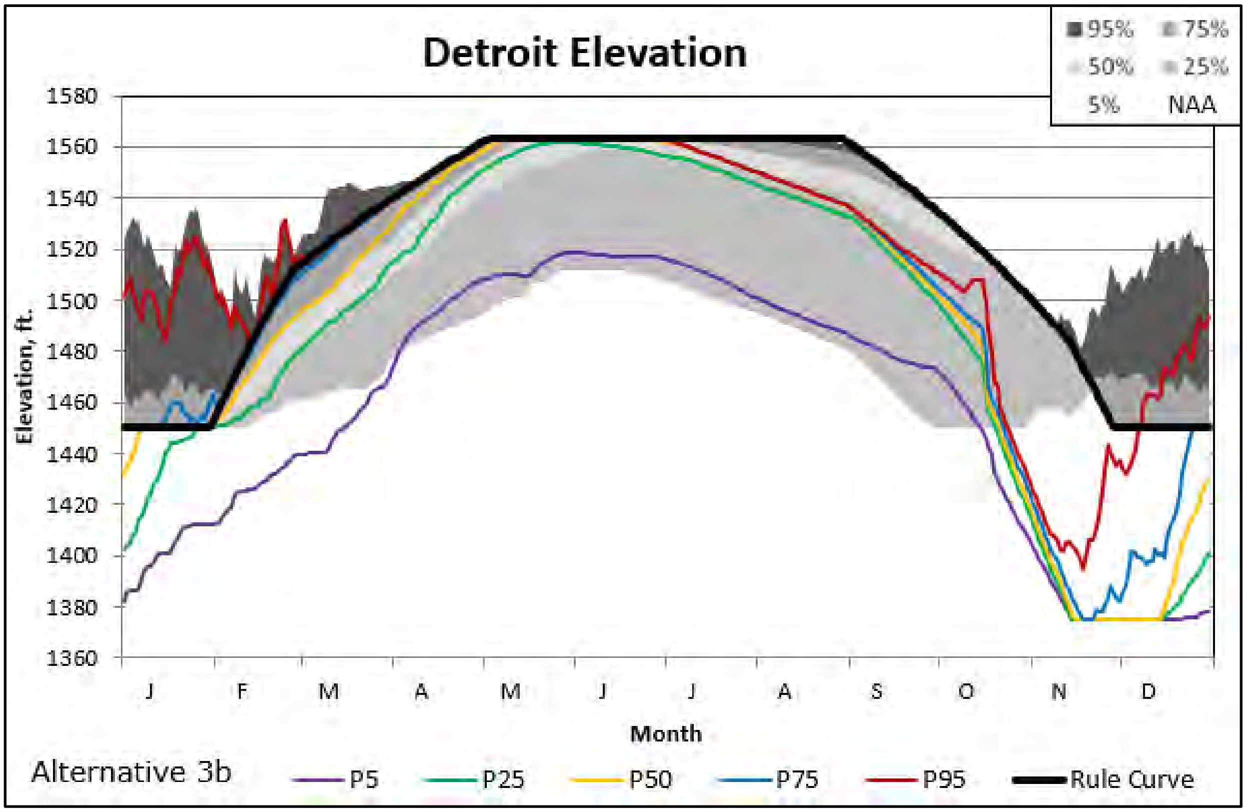



**Figure 3.2-123. Alternative 3B Detroit water surface elevation non-exceedance compared with NAA**

Although there would be generally lower flow during some periods downstream of Detroit as compared to the NAA, the integrated temperature and habitat flow regime targets would be met more often in Alternative 3B than the BiOp targets are in the NAA. The largest miss is in late November of the driest years (P05 line). The reservoir water surface elevation would already be lowered to the deeper fall reservoir drawdown elevation and then passes inflow for the duration of the operation. The inflow would not be enough to meet the target in these years but is enough in 75 percent of the period of record (P25 line).

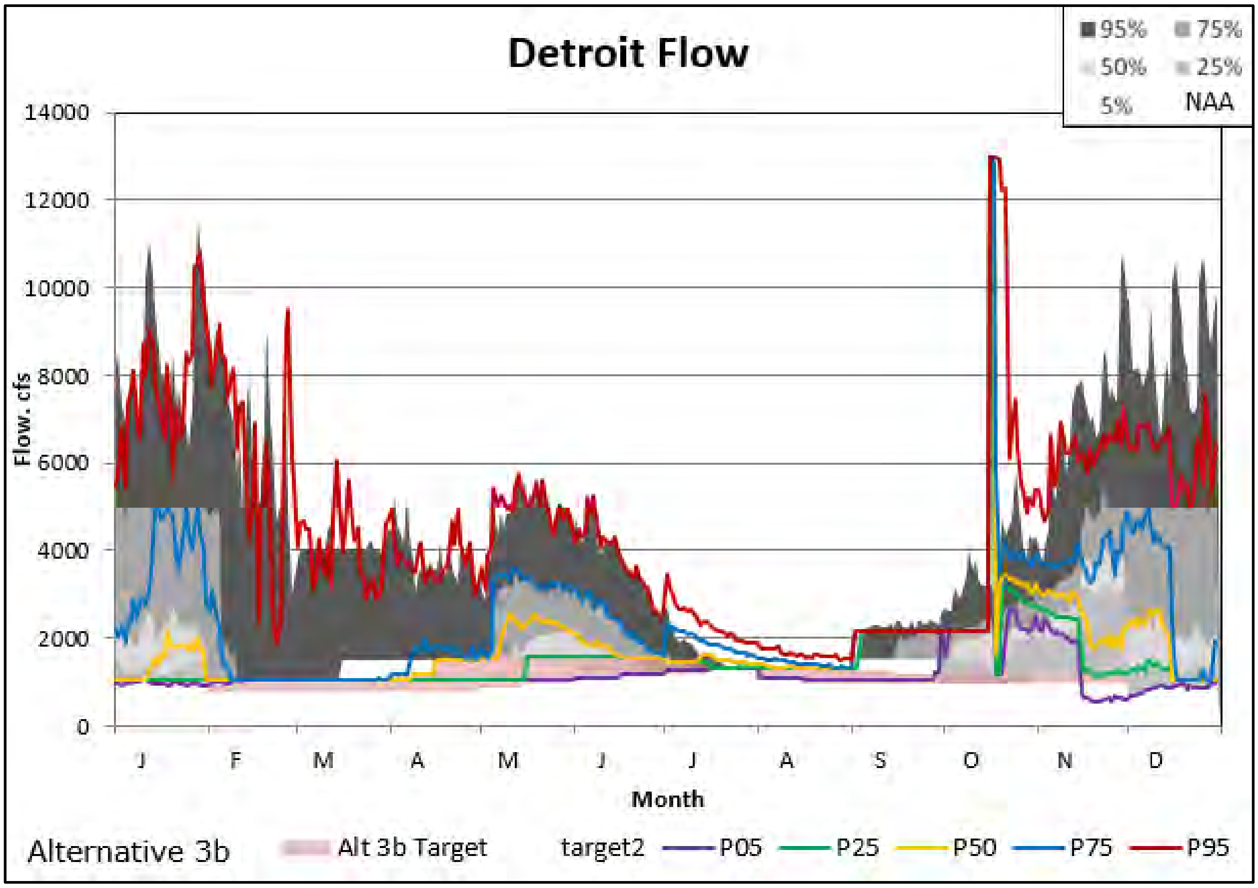



**Figure 3.2-124. Alternative 3B Detroit outflow non-exceedance compared with NAA**

Green Peter Reservoir (Figure 3.2-125) would operate with both spring and fall reservoir drawdowns to elevation 780 feet for Alternative 3B. These elevations would be achieved about half the time due to higher inflows and decreased outlet capacity. An average year (P50 line) would see the reservoir passing inflow from August to October, which is typically below the downstream target streamflow.

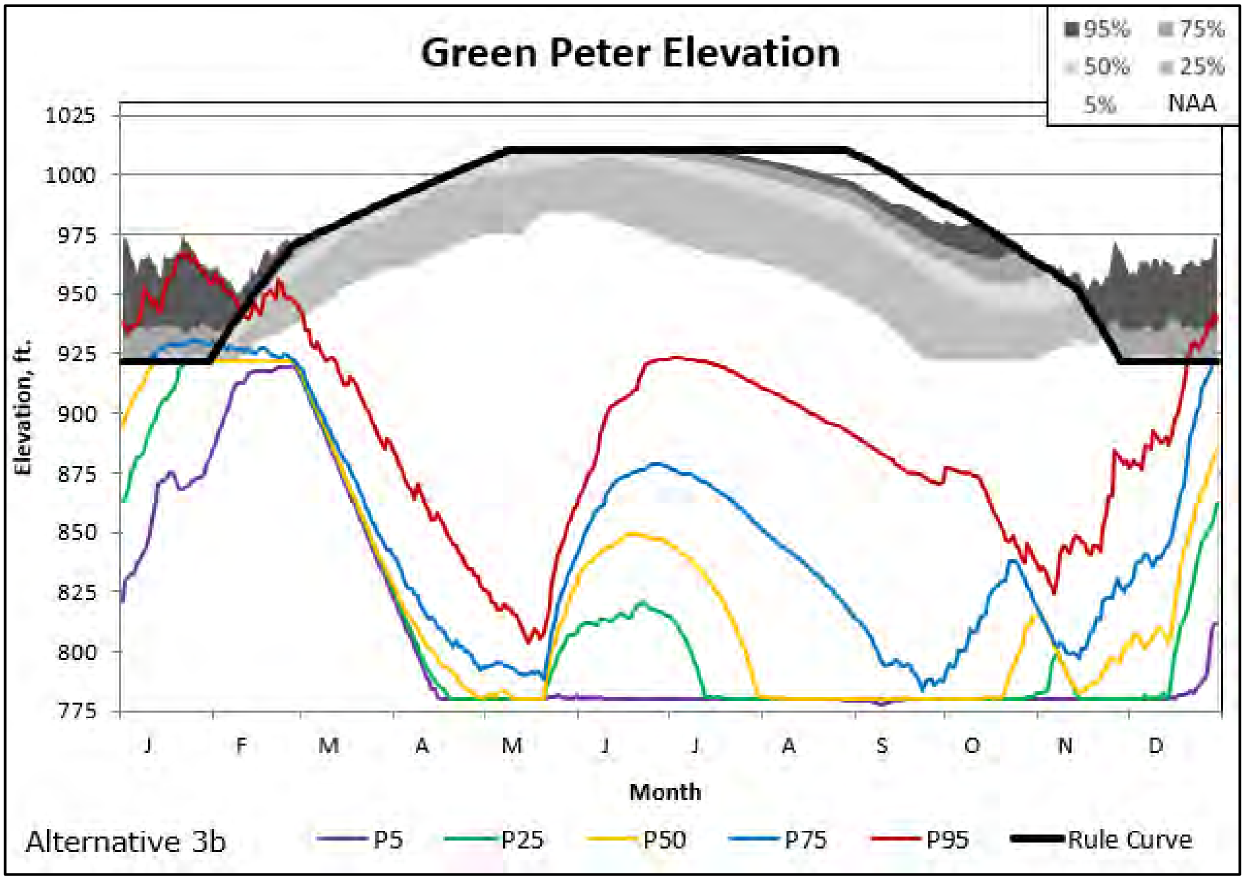



**Figure 3.2-125. Alternative 3B Green Peter water surface elevation non-exceedance compared with NAA**

During an average and drier year, Foster Reservoir (Figure 3.2-126) would also draft down to its minimum pool to supplement downstream flows. Alternative 3B is the only alternative in which this occurs. Foster pool is less than one-tenth the volume of Green Peter pool (28.3 and 312.5 Kaf, respectively), so it would reach its minimum pool elevation within a few weeks of starting to draft. An average year would see the Foster water surface elevation start to fall in early August and the driest years would see it start to fall in the middle of June.

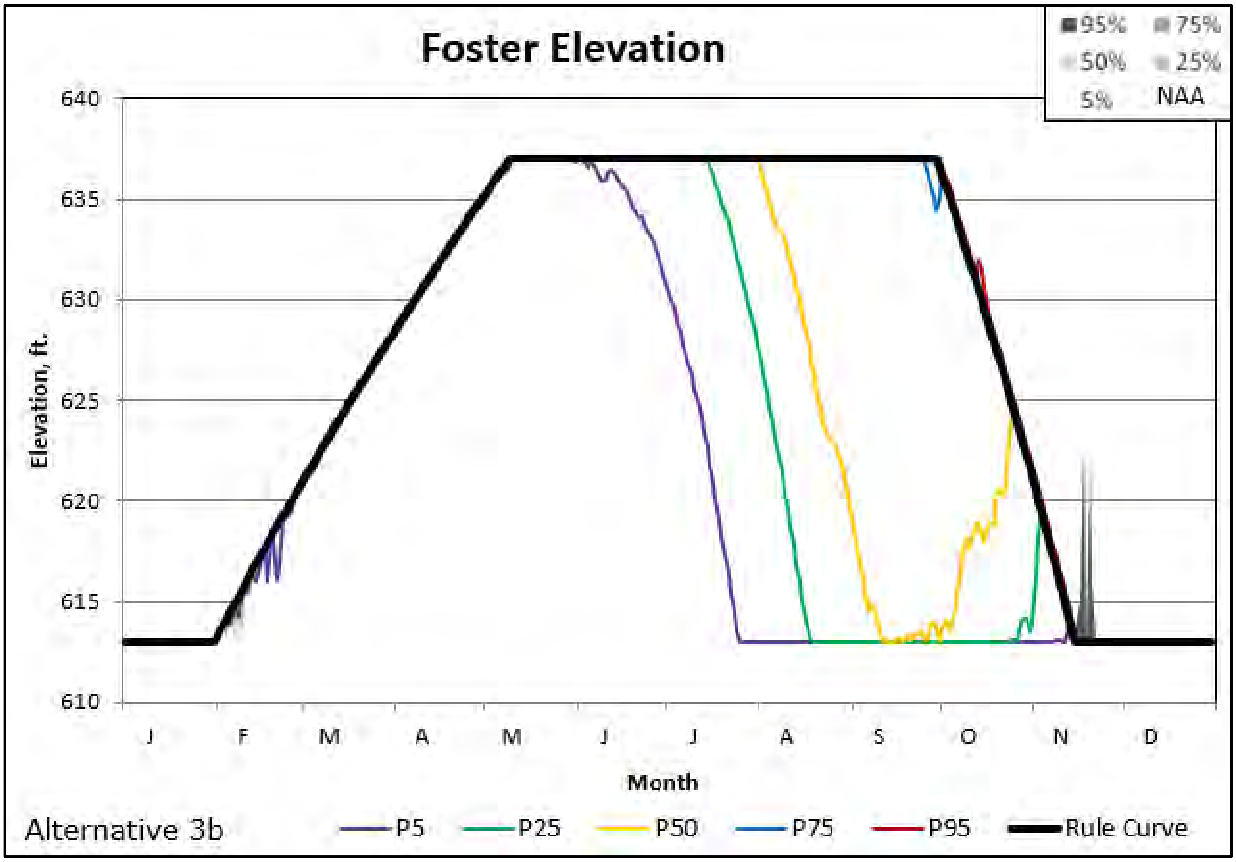



**Figure 3.2-126. Alternative 3B Foster water surface elevation non-exceedance compared with NAA**

The flow downstream of Foster – which combines the output from Foster, Green Peter, and the South Santiam upstream of Foster – would change greatly from the NAA (Figure 3.2-127). Spring flows would be higher across water years as Green Peter releases water for its spring reservoir drawdown. Flows fall suddenly in mid-May as Green Peter starts to refill afterward. The lower bound of the integrated temperature and habitat flow regime target would only be met in wetter-than-average years (P75 line) and the driest years fall short from May until November, even as Alternative 3B uniquely drafts Foster Reservoir's small storage capacity. The typical outflow from Foster in the fall for drier-than-average year would be 100 to 350 cfs, compared to the target flow of 840 cfs.

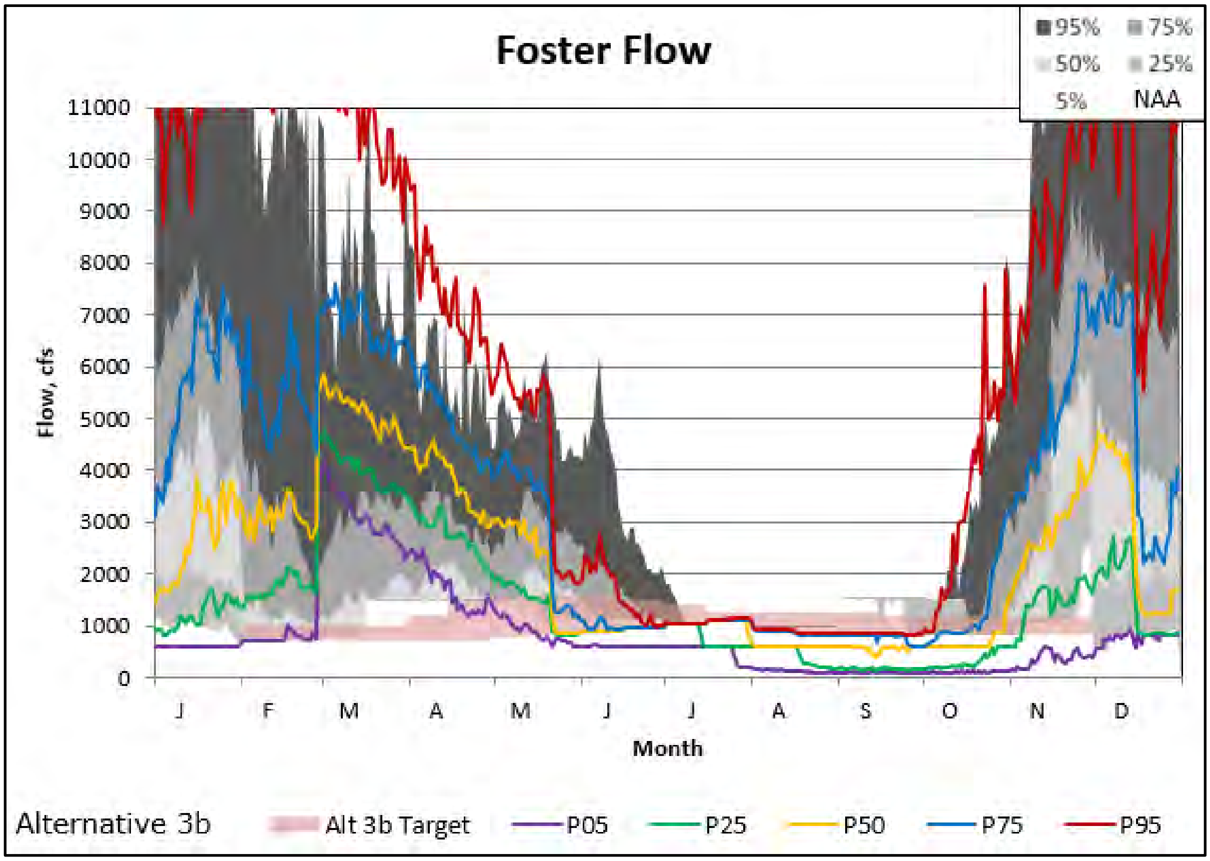



**Figure 3.2-127. Alternative 3B Foster outflow non-exceedance compared with NAA**

The Santiam at Jefferson (Figure 3.2-128) would be affected by the changes at Detroit – in the North Santiam subbasin – and Green Peter – in the South Santiam subbasin. Higher flows would be evident when the reservoirs draft to the drawdowns (principally March for Green Peter and October for both) compared to the NAA. There would also be a larger variation in flow in the summer, with more flow in the wettest years and less flow in the driest years. There would be much less change in the seasonal flow pattern as compared to Alternatives 1 and 4, as the storage aspects of those Alternatives are constrained by the drawdowns.

Although there are many relatively minor differences, the largest difference between Alternatives 3A and 3B is the larger outflow from Detroit in preparation for the deeper fall reservoir drawdown. Although it is a notable spike in flow for October, it is well within bankfull flows and very unlikely to be the highest flow in any given year.

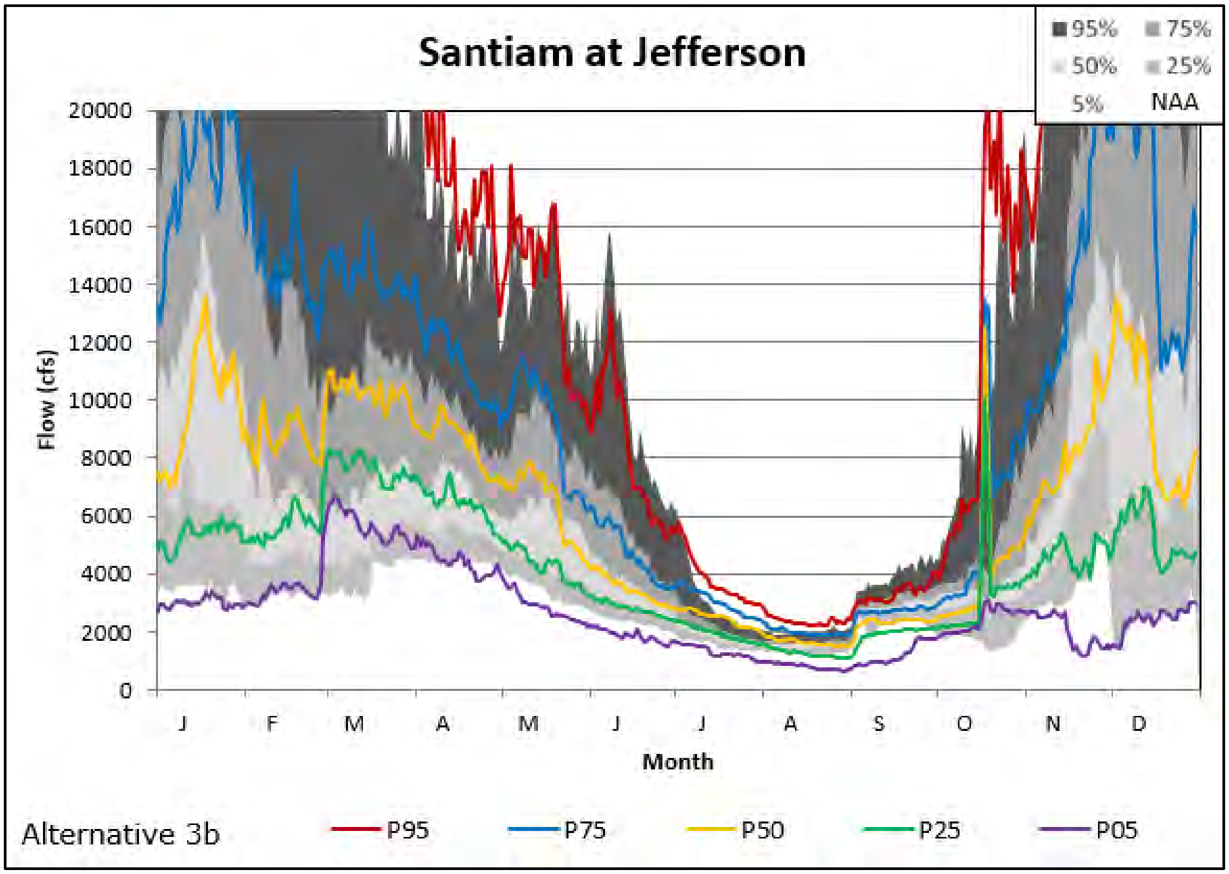



**Figure 3.2-128. Alternative 3B Santiam River at Jefferson flow non-exceedance compared with NAA**

*3.2.2.8.2 Long Tom Subbasin*

As explained in the NAA, Fern Ridge reservoir (Figure 3.2-129) is operated for recreation and fish and wildlife habitat in the conservation season and typically seeks to maximize the reservoir pool during the summer. Since Fern Ridge has a large surface area and small volume compared to the other WVS reservoirs, there is limited scope to change its operation and the water surface elevations within Fern Ridge would remain nearly the same as the NAA. Downstream flows at Monroe would remain similarly unchanged for Alternative 3B.

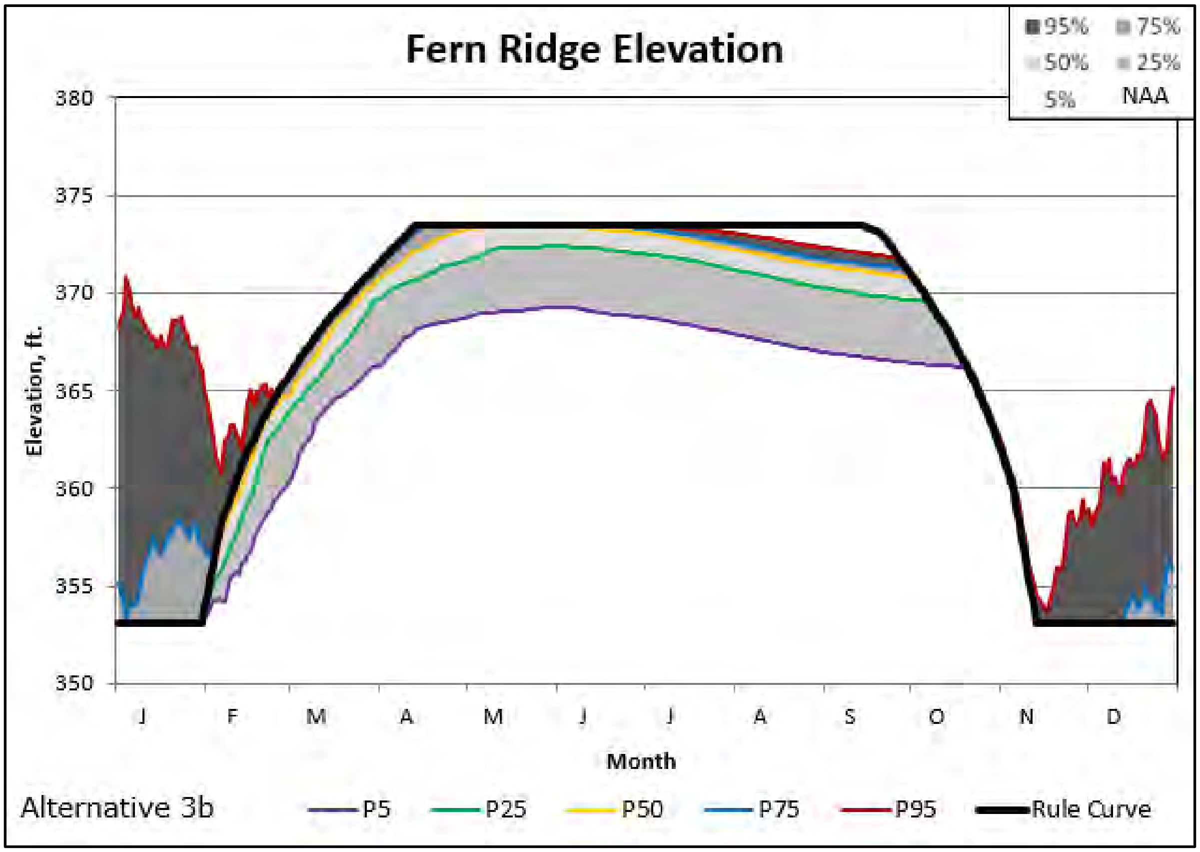



**Figure 3.2-129. Alternative 3B Fern Ridge water surface elevation non-exceedance compared with NAA**

*3.2.2.8.3 McKenzie Subbasin*

Like Green Peter reservoir in the Santiam subbasin, Cougar reservoir (Figure 3.2-130) would have both spring and fall reservoir drawdowns. Although Cougar also would have both drawdowns in Alternative 3A, Alternative 3B drafts Cougar significantly lower using the diversion tunnel to elevation 1330 feet instead of the RO to elevation 1517 feet. The reservoir water surface elevation would only be at or above minimum conservation pool at the end of winter and only the wettest summers (P95 line) a substantial change from the NAA. An average year (P50) would achieve the spring reservoir drawdown target elevation, but not the fall elevation.

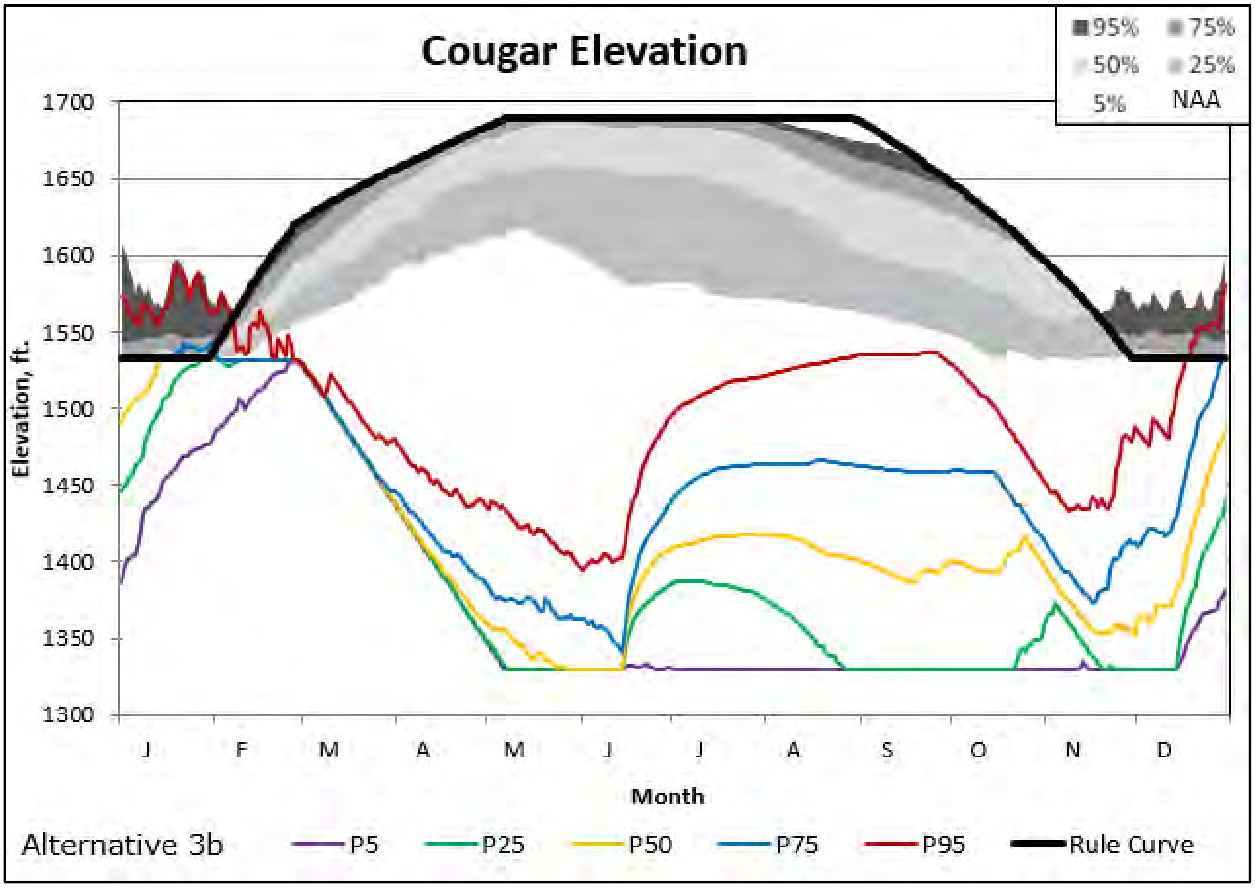



**Figure 3.2-130. Alternative 3B Cougar water surface elevation non-exceedance compared with NAA**

Blue River reservoir (Figure 3.2-131) would fill more frequently in Alternative 3B as compared to the NAA due to the lower downstream integrated temperature and habitat flow regime targets. It would also draft more quickly in the summer to make up for the lower storage volume available from Cougar and has a deeper fall reservoir drawdown to elevation 1165 feet.

Overall, Alternatives 3A and 3B would be very similar at Blue River, except for the driest Octobers. Mainstem flow targets would dictate that Blue River continue to augment instream flows by using the inactive pool in Alternative 3A. In Alternative 3B, other WVS reservoirs – Lookout Point in particular – meet this downstream need in the driest years.

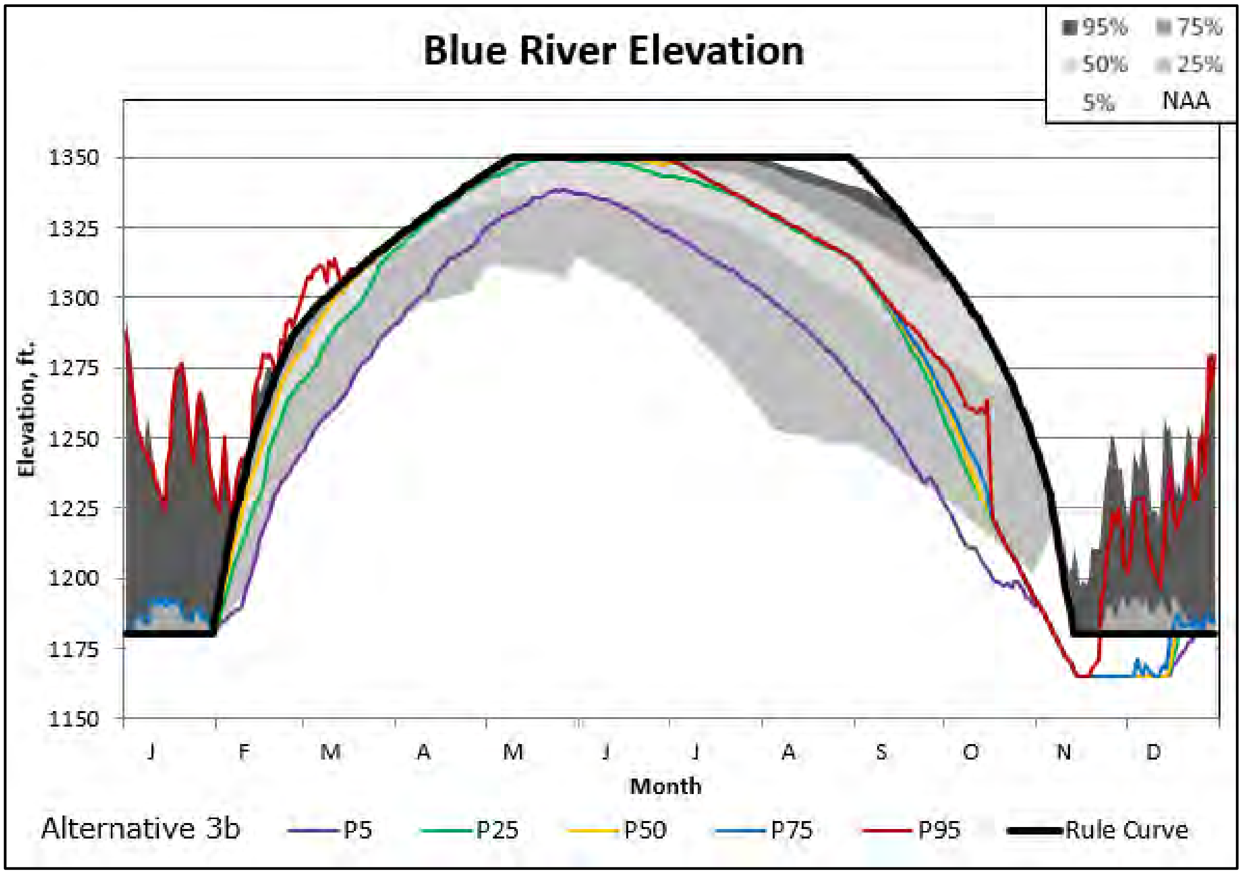



**Figure 3.2-131. Alternative 3B Blue River water surface elevation non-exceedance compared with NAA**

The downstream control point, the McKenzie River at Vida (Figure 3.2-132), shows the combined effect of more and less available conservation storage at Blue River and Cougar, respectively compared to the NAA. The higher flows during March for all years and continuing into April and May of wet years would result from Cougar not filling during conservation season as it does in the NAA. The lower flows during the driest years of April to June are due to Blue River filling more while also meeting the lower minimum downstream integrated temperature and habitat flow regime targets.

During the summer, Alternative 3B flows would be marginally below the NAA as the increased storage at Blue River and no storage at Cougar nearly balance out – Blue River is smaller than Cougar, so flows would be a bit lower across the summer. Despite Cougar's much lower water surface elevations for Alternative 3B as compared to 3A, the amount of volume in the reservoir above the minimum elevation (1330 feet and 1517 feet for 3B and 3A, respectively) is similar across the summer. Therefore, combined with the relatively high baseflow in the McKenzie River, the lower drawdown elevation would only have small effects on the summer and fall flow at Vida.

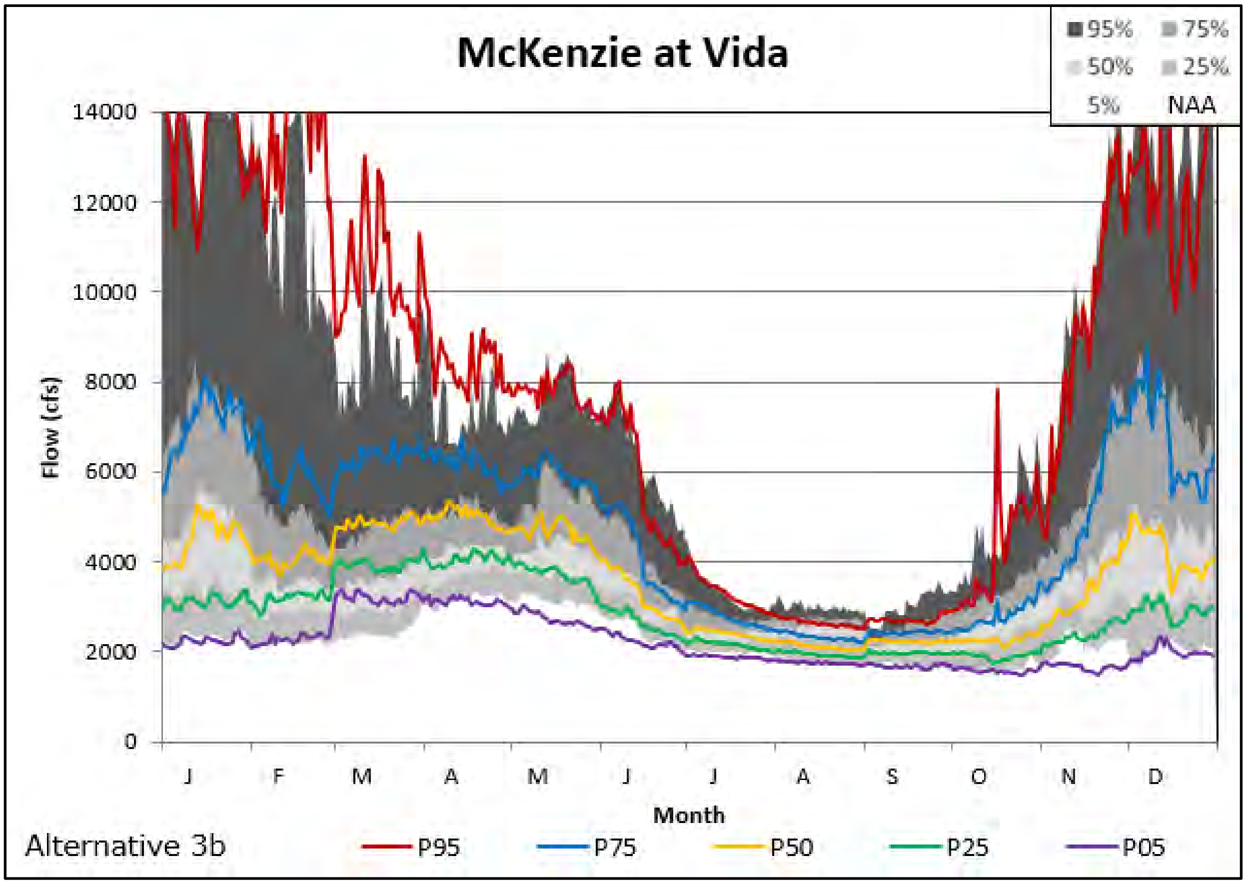



**Figure 3.2-132. Alternative 3B McKenzie River at Vida flow non-exceedance compared with NAA**

### *3.2.2.8.4 Middle Fork of the Willamette Subbasin*

Hills Creek, Lookout Point and Fall Creek would all have deeper fall reservoir drawdowns in Alternative 3B (Fall Creek's is an existing operation in the NAA) and Hills Creek would also have a spring reservoir drawdown. As such, Hills Creek (Figure 3.2-133) does not fill more than about 10 feet above its minimum elevation 75 percent of years during the summer, which is substantially less frequent than the NAA. The drawdown target elevation would be achieved in the wettest years (P95) in contrast to deeper drawdowns at other WVS reservoirs.

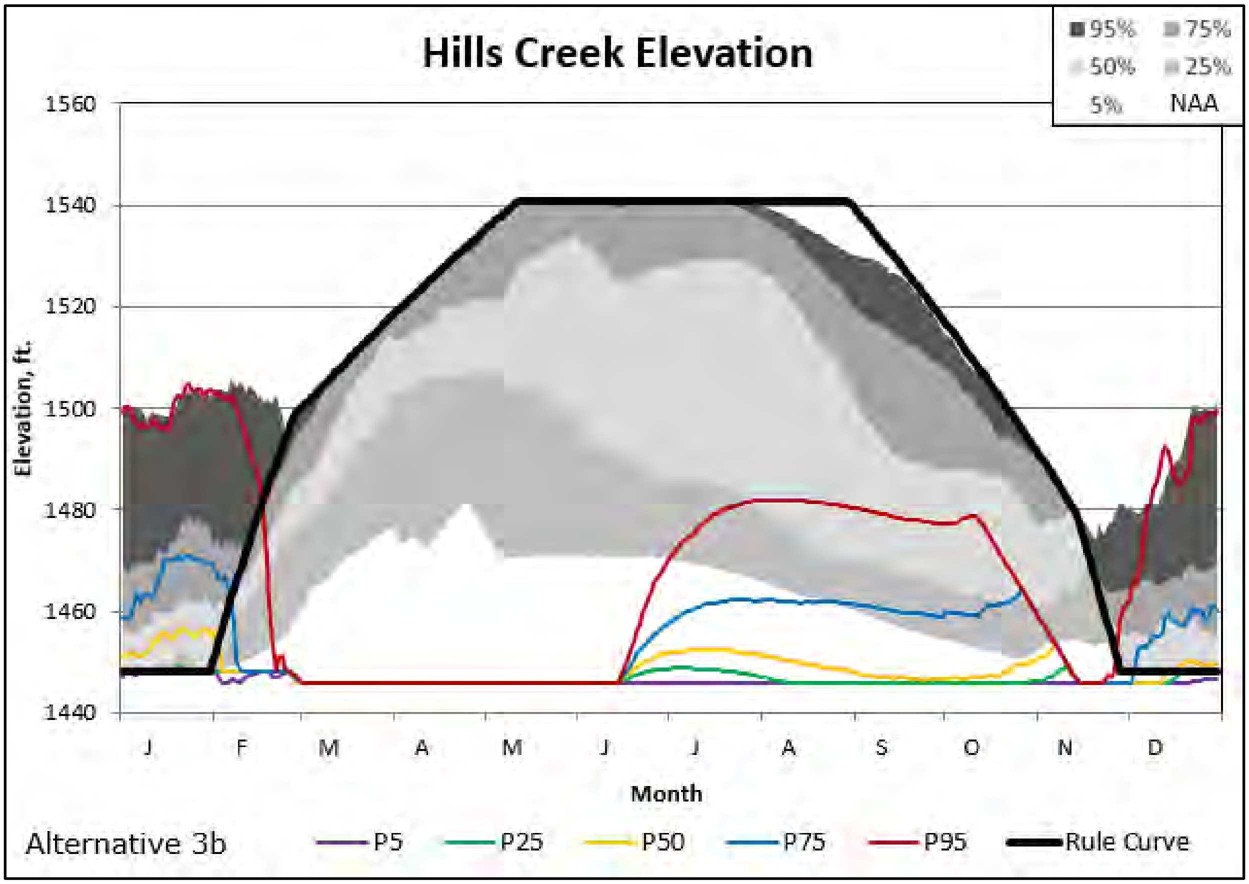



**Figure 3.2-133. Alternative 3B Hills Creek water surface elevation non-exceedance compared with NAA**

During spring conservation storage season, Lookout Point (Figure 3.2-134) would fill more frequently and achieve a higher elevation during dry years as compared to the NAA. This is due to the lower integrated temperature and habitat flow regime targets and some of the water not stored at Hills Creek due to the spring reservoir drawdown there is stored at Lookout Point. Since there would be a lower amount of water stored in the system overall, Lookout Point would draft earlier than in the NAA before releasing water at a higher rate than the NAA for the deeper fall reservoir drawdown. The drawdown target elevation would usually, but not always, be achieved (the P75 line reaches the target, but the P95 line does not).

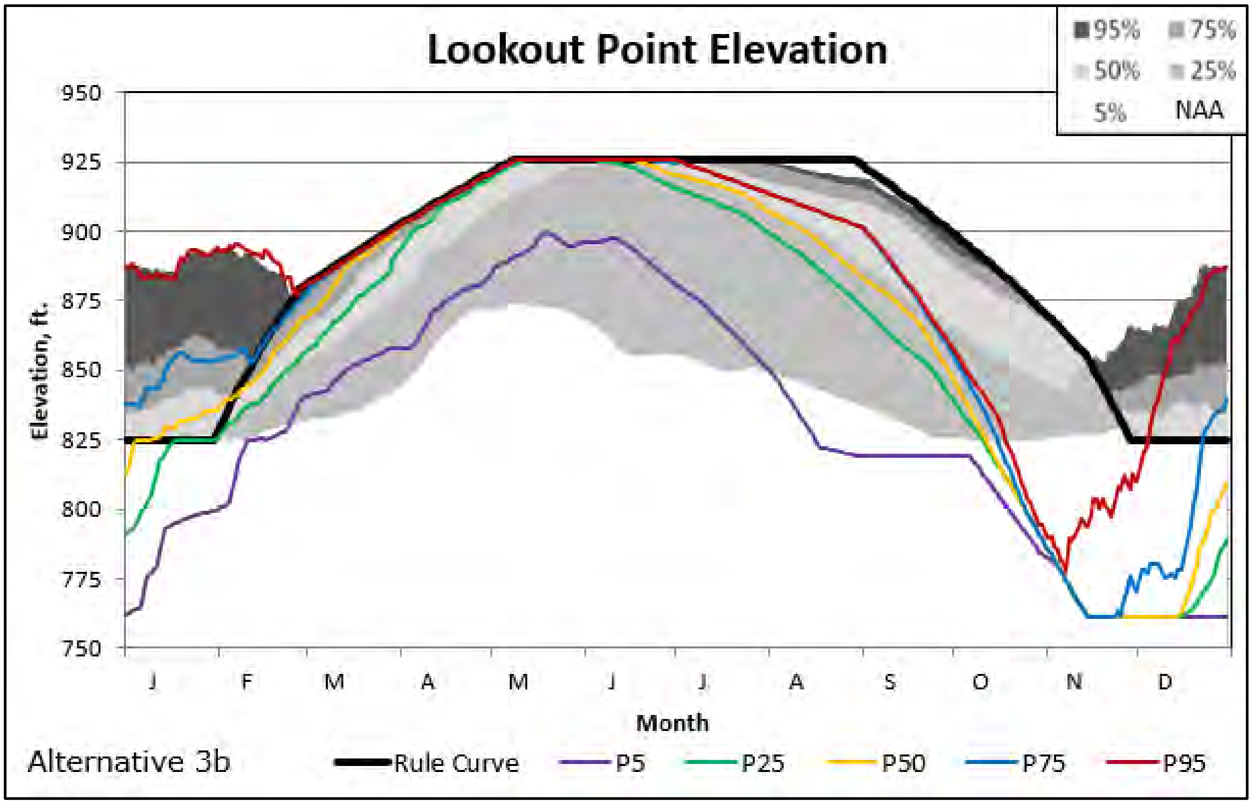



**Figure 3.2-134. Alternative 3B Lookout Point water surface elevation non-exceedance compared with NAA**

Fall Creek (Figure 3.2-135) water surface elevations and outflows would be very similar to the NAA, which already implements a deeper fall reservoir drawdown to the same elevation as in Alternative 3B.

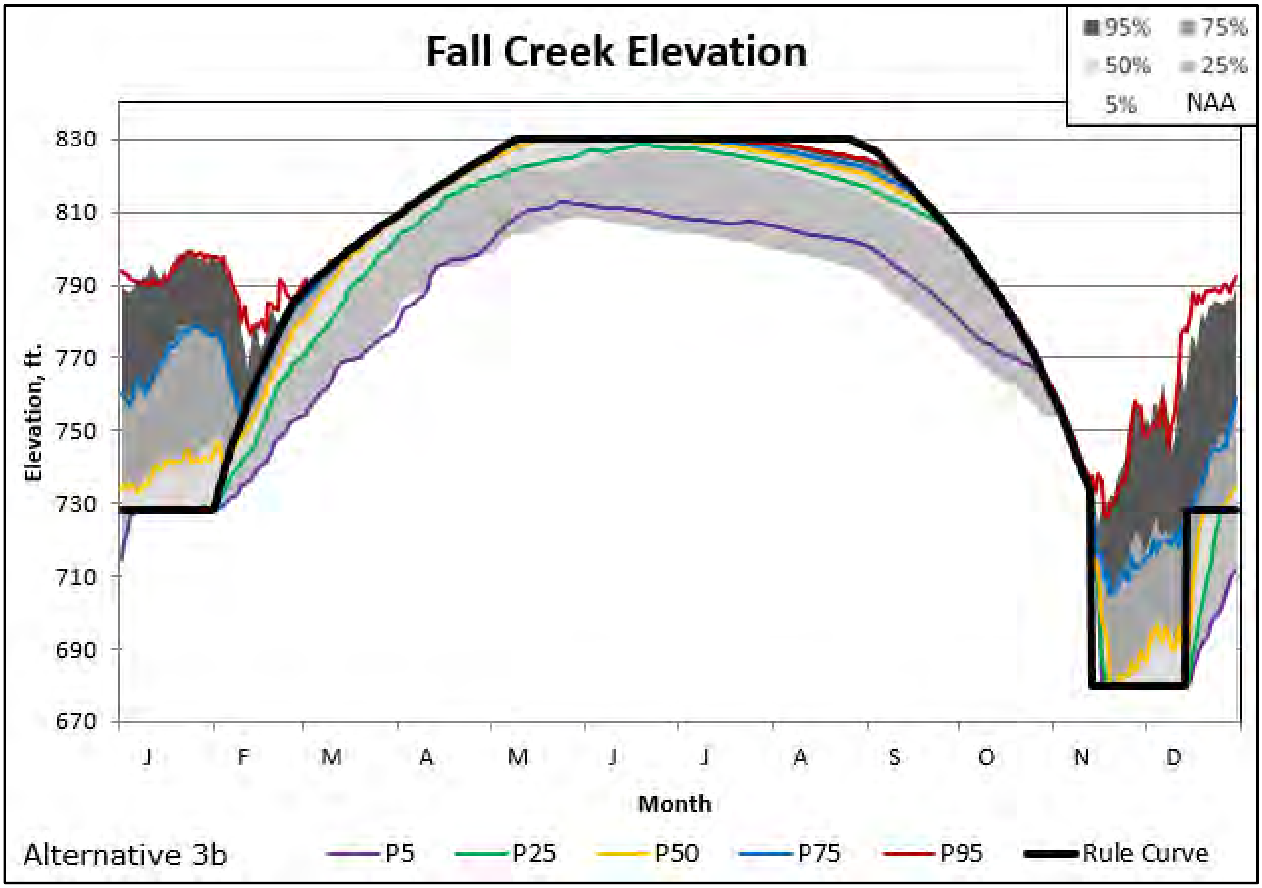



**Figure 3.2-135. Alternative 3B Fall Creek water surface elevation non-exceedance compared with NAA**

The flows at the control point for the Middle Fork subbasin WVS dams at Jasper (Figure 3.2-136) would be more like the NAA for Alternative 3B than it would be for Alternative 3A. There are a couple reasons for this. Since Hills Creek, which is upstream of Lookout Point, has the spring reservoir drawdown in Alternative 3B, Lookout Point can store some of the water that flows from Hills Creek during the spring. Lookout Point is also more than 40 percent larger than Hills Creek (336.4 Kaf and 234 Kaf, respectively), so Alternative 3B conservation season storage volumes are higher compared to 3A.

The driest years during April to June (P05) are due to the lower integrated temperature and habitat flow regime targets downstream, which are met in Alternative 3B. The lower flows during the driest August through October periods coincide with Lookout Point reaching its minimum water surface elevation outside of the drawdown target, at which point it would pass inflow, which would be lower than the augmented flow in the NAA.

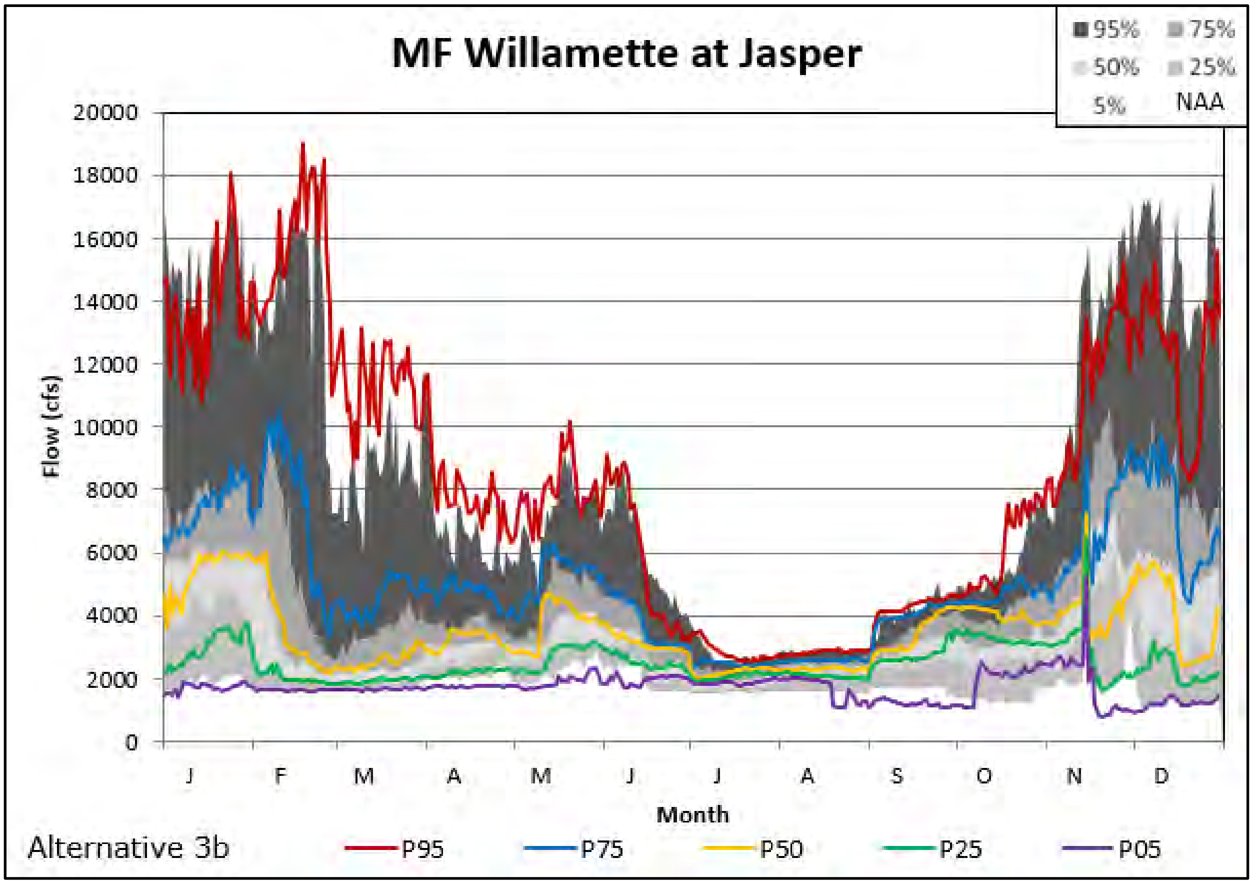



**Figure 3.2-136. Alternative 3B Middle Fork of the Willamette River at Jasper flow non-exceedance compared with NAA**

*3.2.2.8.5 Coast Fork of the Willamette Subbasin*

Dorena and Cottage Grove reservoir elevations would behave very similarly in Alternative 3A, as shown in Figures 3.2-137 and 3.2-138, respectively. The refill to slightly higher levels than the NAA due to the lower integrated temperature and habitat flow regime targets downstream. Reservoir storage would be similar for average and wet years throughout the summer and fall. They would draft faster from higher initial water surface elevations in dry years as these reservoirs make up for the lower storage elsewhere in the system. In especially dry falls, the reservoirs would augment instream flows by using the inactive pool. This operation would be activated a bit more often in Alternative 3B as opposed to Alternative 3A.

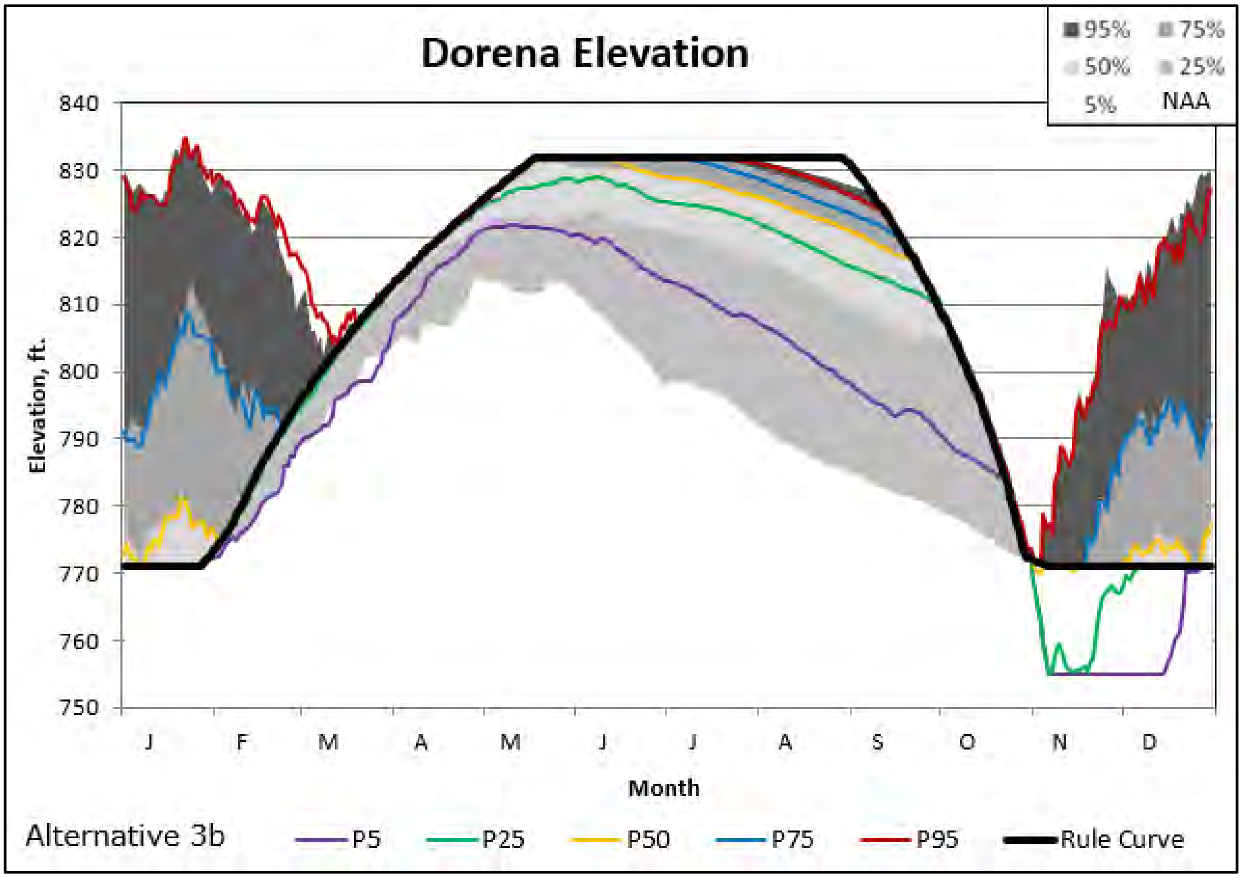



**Figure 3.2-137. Alternative 3B Dorena water surface elevation non-exceedance compared with NAA**

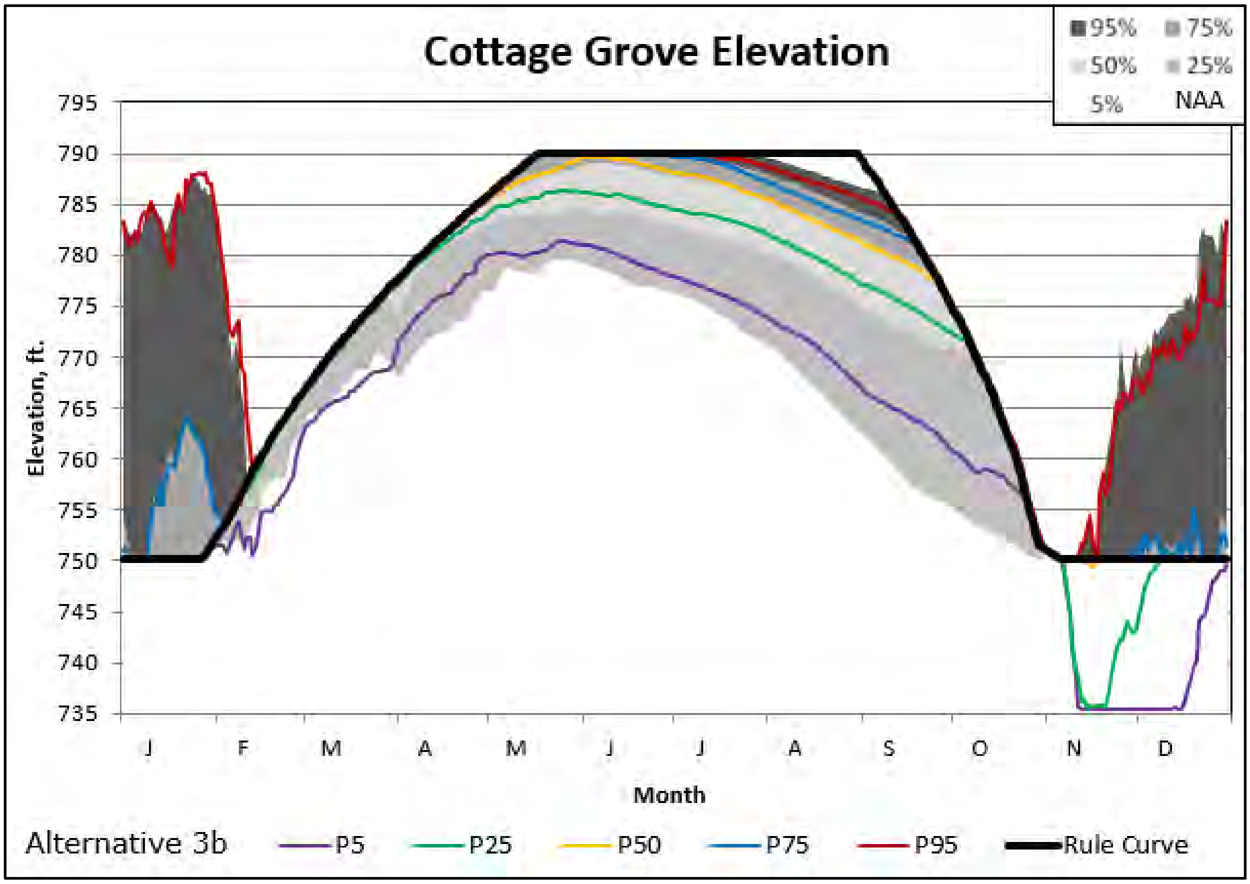



**Figure 3.2-138. Alternative 3B Cottage Grove water surface elevation non-exceedance compared with NAA**

The flow at Coast Fork of the Willamette River at Goshen (Figure 3.2-139) would vary most from the NAA in dry years. The additional stored water accumulated in Dorena and Cottage Grove would be evident by the decreased flow from April to June and increased flow July to October as the reservoirs release that water. Although there are minor differences, Alternative 3A and 3B are similar at Goshen from a hydrologic perspective.

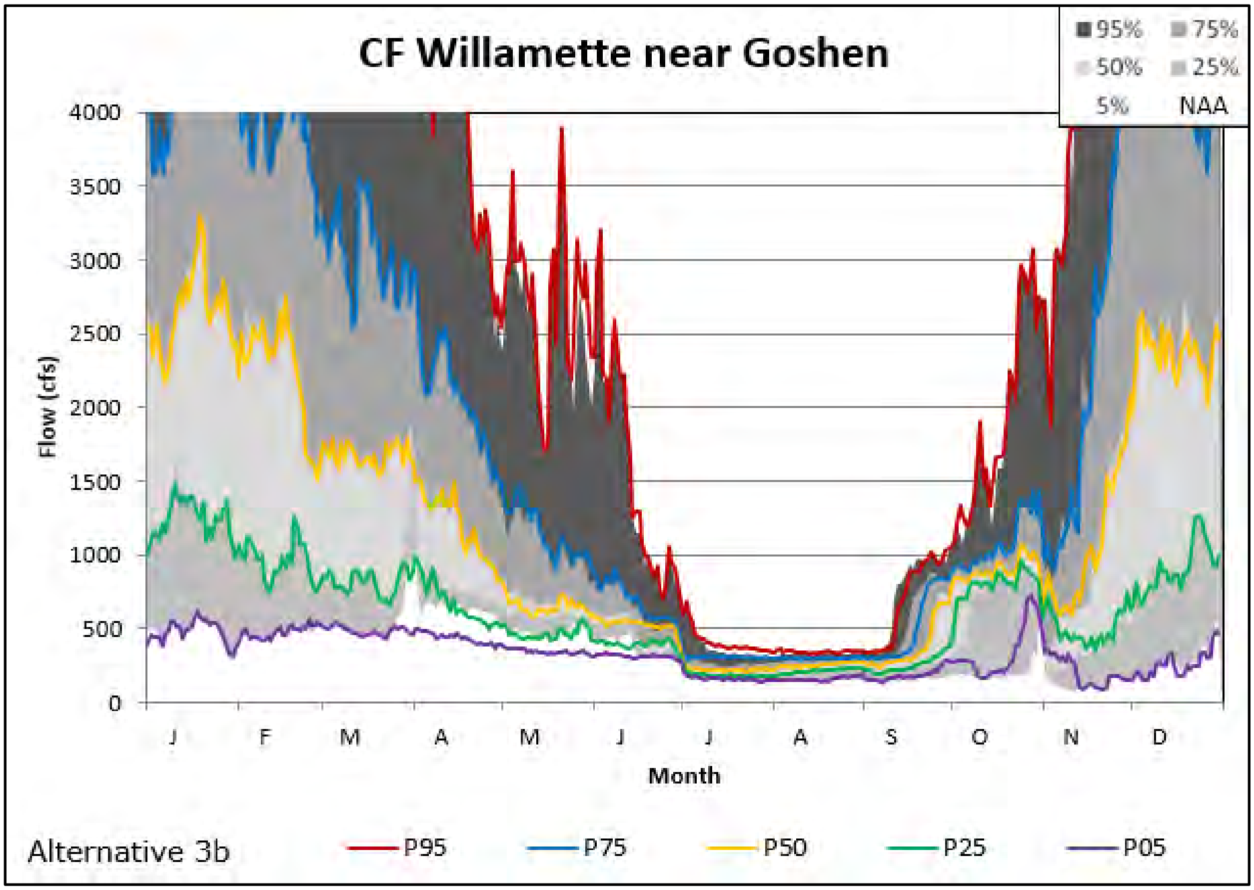



**Figure 3.2-139. Alternative 3B Coast Fork of the Willamette River at Goshen flow non-exceedance compared with NAA**

### *3.2.2.8.6 Mainstem Willamette River*

The Alternative 3B flow targets on the mainstem Willamette River at Albany and Salem (Figures 3.2-140 and 3.2-141, respectively) are the integrated temperature and habitat flow regime targets, which are lower than the BiOp targets in the NAA and modify the target at Salem during warm weather (the target box in the figure). Section 2.2.1, Flow Measures, contains a more detailed explanation of these flow targets.

In wet years Alternative 3B would have consistently higher flow during the springtime at both Albany and Salem as compared to the NAA. The driest years would have lower flow in the spring due to the lower flow target at Salem.

After the end of the WVS spring reservoir drawdowns, flows would decline across all years, but not as steeply as Alternative 3A. The integrated temperature and habitat flow regime target would be met more often during dry years than the NAA meets the 2008 BiOp target. During wetter years, lower overall system storage would mean less flow (P95 and P75 lines) than the NAA. In the driest years (P05 line), flows would be below the target for about 2 months instead of almost 4 months in the NAA. Across all water year types, flows would be higher at Albany for Alternative 3B than Alternative 3A. This is largely due to the Middle Fork spring reservoir drawdown switching from Lookout Point to Hills Creek in Alternative 3B; Lookout Point would be able to store some of the water that Hills Creek releases during its spring reservoir drawdown.

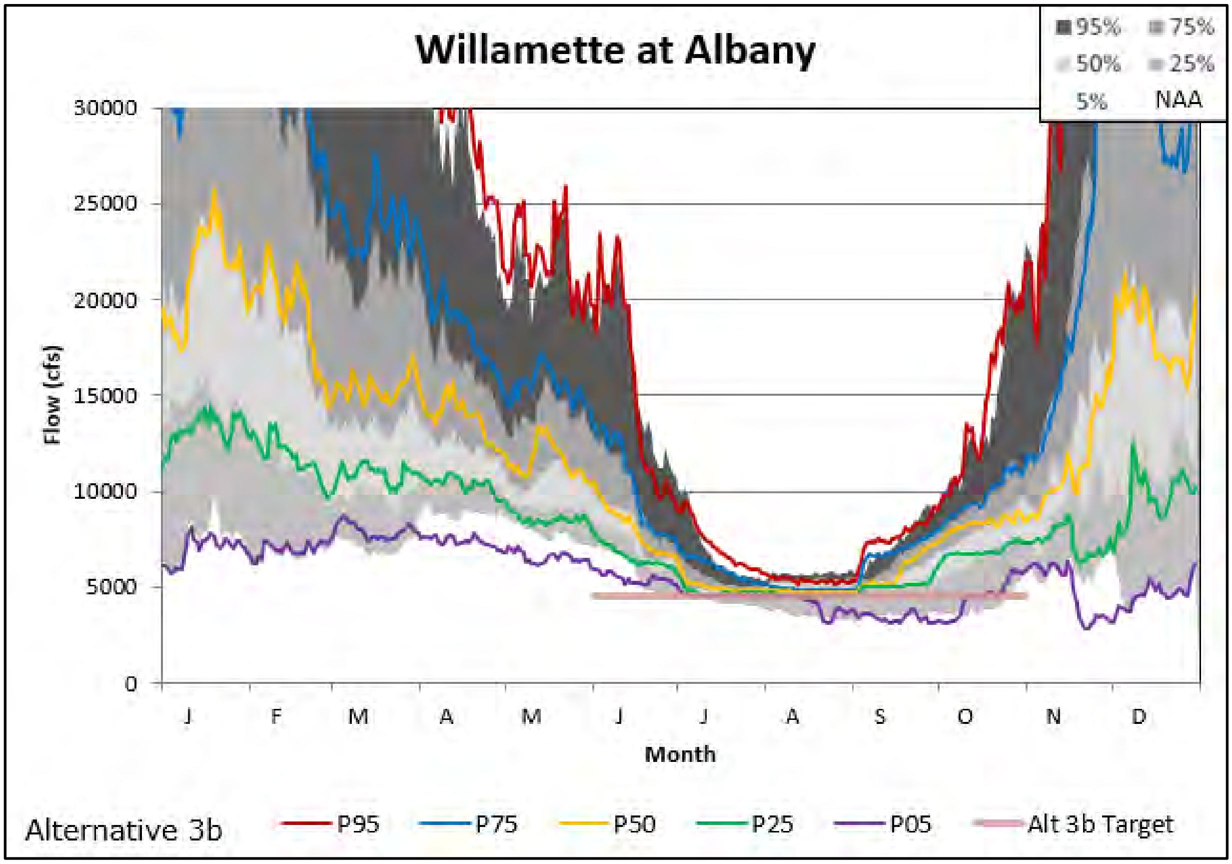



**Figure 3.2-140. Alternative 3B Willamette River at Albany flow non-exceedance compared with NAA**

Flows at Salem would more consistently meet the integrated temperature and habitat flow regime target for Alternative 3B than Alternative 3A, again due to the contributions of Lookout Point. Spring flows would be lower for drier years, as the flow target is lower than the NAA, and higher for wetter years, as the WVS reservoirs with drawdowns are releasing water they would have stored in the NAA.

Summer flow at Salem would be generally somewhat less than the NAA but would only miss the integrated temperature and habitat flow regime target during the driest years (P05 line), when Lookout Point reaches its minimum summer pool. This coincides with low flows at Albany, but augmentation from the Santiam subbasin means there are fewer missed days at Salem.

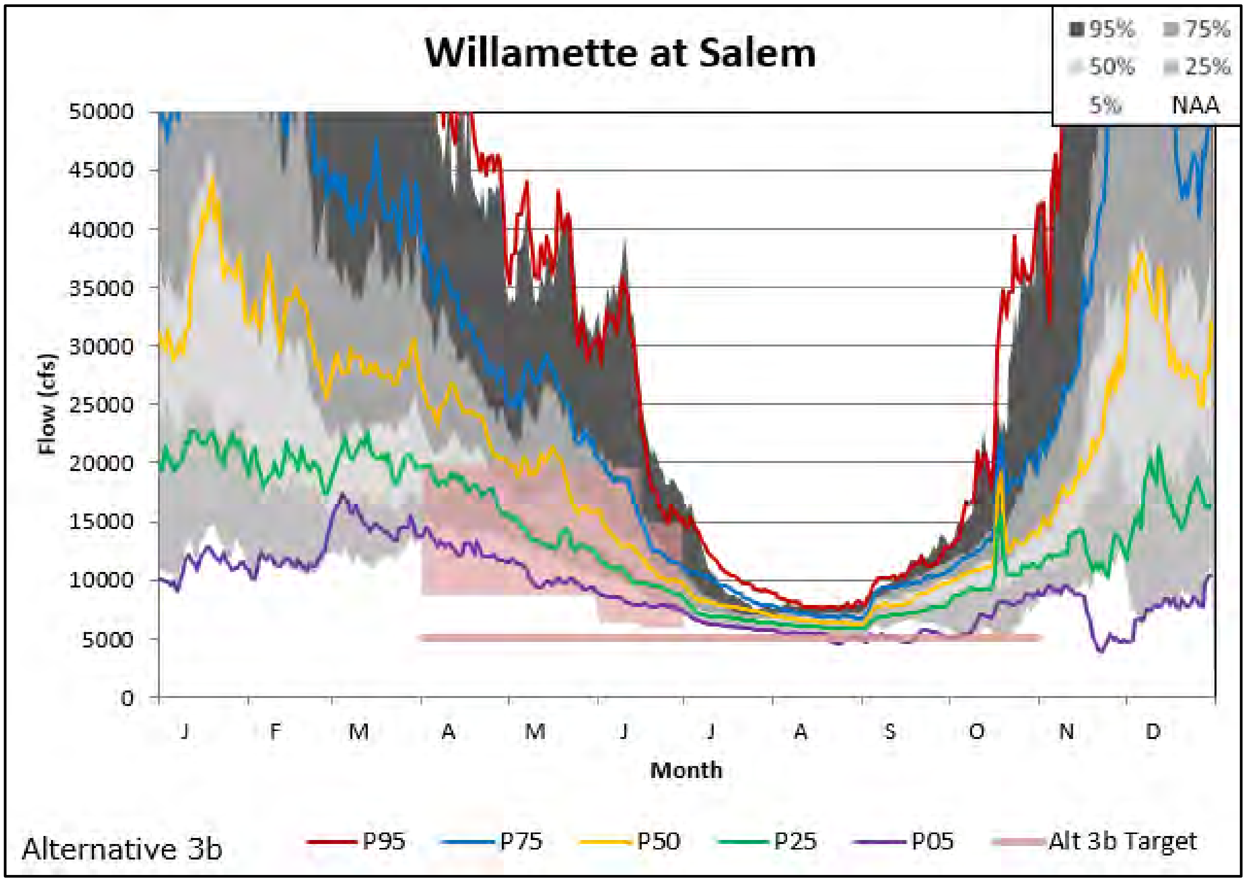



**Figure 3.2-141. Alternative 3B Willamette River at Salem flow non-exceedance compared with NAA**

*3.2.2.8.7 Near-Term Operations Measure*

See Alternative 2A, Section 3.2.2.4.7, for description of effects due to the Near-Term Operations Measure.

*3.2.2.8.8 Climate Change*

Climate change hydrologic factors such as seasonal flow volume shifts may stress the WVS under Alternative 3B operations. Specifically, future increases in median wintertime flow volumes and average deceases in summertime baseflows will exacerbate effects already present in Alternative 3B. Climate change effects, and potential implications as discussed below, draw on the climate change projection and trend information provided in the climate change appendices.

Across the WVS, lower reservoir pool elevations and flow releases for downstream flow targets are likely in the future. Spring inflow quantity and timing is projected to be more variable in the future as climate change trends take hold. Limited to no snowpack is a consequence of projected warming in the Valley and conversion of snowpack to wintertime flows. The projection for even drier, warmer, and earlier arriving summers means that the spring reservoir drawdowns will typically prevent refill. The spring reservoir drawdowns at Hills Creek and Cougar end in the middle of June and at Green Peter in middle of May, well after the projected decline in inflow.

Both the Albany and Salem flow targets will be met less frequently compared to the NAA with projected lower late spring and summer flow, though the differences will be less drastic than in Alternative 3A. There are a couple reasons for this. The South Santiam subbasin has a lower average elevation, so is projected to be relatively less affected by decreasing inflows. Therefore, Green Peter would be able to fill more often after its Alternative 3B spring reservoir drawdown than Detroit (which has a spring reservoir drawdown in Alternative 3A). Also, Lookout Point can store some of the water released from Hills Creek during the spring reservoir drawdown, increasing its chance of complete refill.

After the deeper fall reservoir drawdowns, there is additional storage space between the minimum drawdown elevation and the maximum flood storage elevation. It will typically take until middle of January (though timing varies throughout the WVS) for reservoirs to return to their current rule curve elevation under the NAA. Downstream winter flows could be kept similar to the NAA with this additional storage capacity, despite projected increased winter peak flow and volume.

#### *3.2.2.9 Alternative 4 – Improve Fish Passage with Structures-Based Approach*

From a hydrologic perspective, Alternative 4 is similar to Alternative 1, with a different set of flow targets in the subbasins below the dams and in the mainstem Willamette River. The "Integrated Temperature and Habitat Flow Regime" replace the 2008 NMFS BiOp in the NAA and the Congressionally authorized minimum flows in Alternative 1. Like Alternative 1, Alternative 4 shifts the release of stored water from the spring into the summer and fall, but integrated temperature and habitat flow regime targets are generally higher and more variable than those in the Congressionally authorized minimum flows.

Briefly, the integrated temperature and habitat flow regime would modify the minimum targets at a WVS reservoir if it is at more or less than 90 percent of rule curve elevation. Flows would be reduced within a range down to minimums needed for fish survival when reservoirs are under the 90 percent threshold. However, these are adaptive within a water year and can return to return to levels higher than the NAA 2008 BiOp flows downstream of the dams if reservoir levels increase.

At the mainstem Willamette control points – Albany and Salem – flow targets would be reduced to 4,500 and 5,000 cfs, respectively. The higher NAA 2008 BiOp targets are designed to keep the river from getting too hot, as well as meet other goals so much more water would be added in the spring. As a replacement, the integrated temperature and habitat flow regime would require additional flow based on the air temperature, with total flow minimum at Salem ranging from 5,900 cfs to 19,800 cfs. This allows the WVS to store additional water when it is not needed to keep the river, and fish in it, cooler than the NAA.

In general, Alternative 4 has limited effects during an average or wet year in the WRB. The reservoirs fill during these years while meeting downstream flow targets. Summer flows are sometimes a bit higher due to the reservoir reaching maximum pool somewhat earlier than normal and therefore passing inflow sooner, but flow differences are minimal.

Alternative 4 would alter storage in drier than average years, and especially the 25 and 5 percent non-exceedance (P25 and P05 in the figures) years, shifting flow releases from April to June into July through October. This would result in less flow compared to the NAA earlier in the year during the April to June period. Later flow targets from July to October would be met more frequently due to the additional accumulated stored water. Compared to Alternative 1, the flows are similar or higher across the WVS, so reservoir elevations would be somewhat lower than Alternative 1.

Although there would be many structural actions in Alternative 4 at the WVS dams to aid fish survival, many of these would not affect the flow out of any WVS dam. Only those structures that affect some aspect of flow, such as outlet choice, are included in this analysis. An example of an excluded structure is a WTC tower, which allows for greater control of the temperature of the water released from the dam but ultimately uses the same regulating outlet as without the WTC tower in place. A more detailed analysis of Alternative 4 by subbasin follows.

The shift in releases of stored water to a different season would be very noticeable throughout the basin and would bring long term changes to the WRB. Effects from the Alternative 4 to hydrologic processes: Major as compared to the NAA.

#### *3.2.2.9.1 Santiam Subbasin*

Detroit reservoir would fill more often during conservation use season and would achieve a higher elevation when it does not fill, as shown in Figure 3.2-142, as compared to the NAA. The integrated temperature and habitat flow regime flow target would be lower than the NAA flows during drier years. More water would be released from storage during average and wetter years, meaning the reservoir water surface elevation would meet the rule curve later in the year at levels above the P50 non-exceedance line.

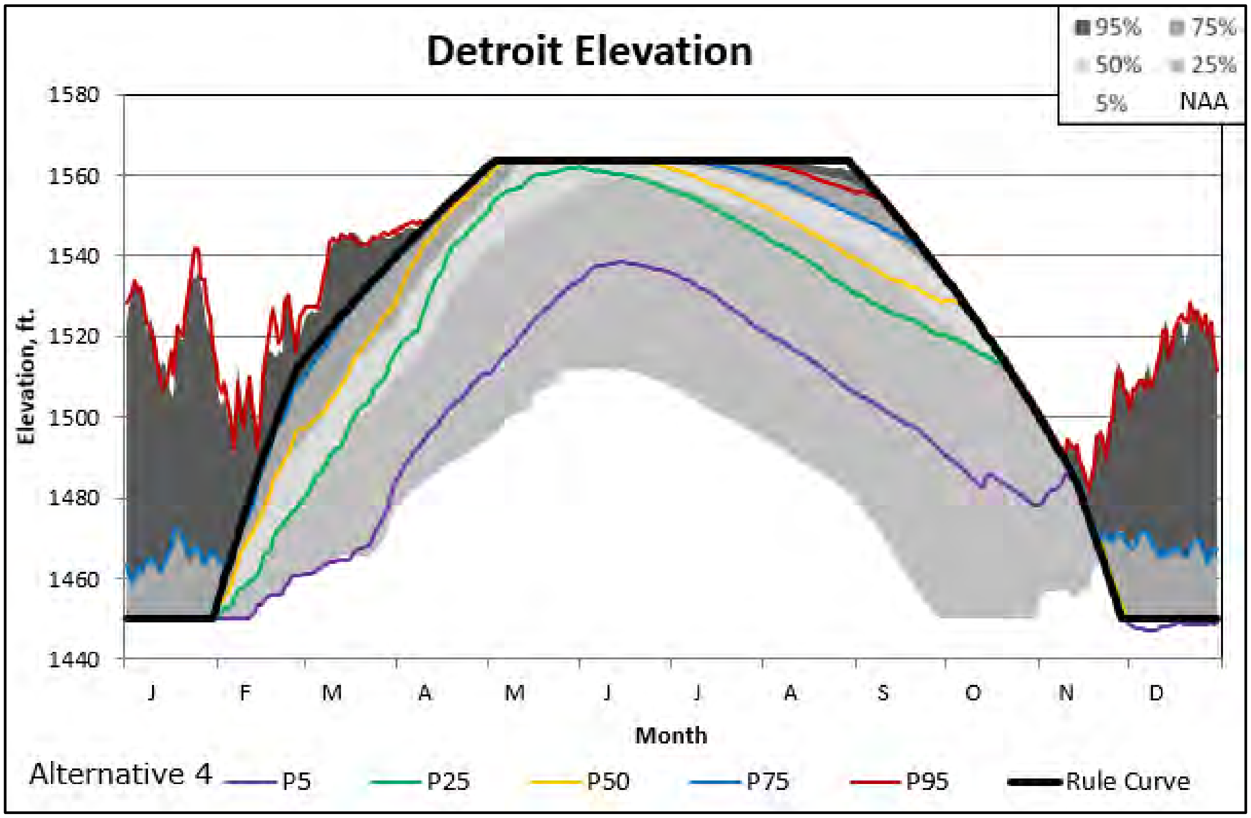



**Figure 3.2-142. Alternative 4 Detroit water surface elevation non-exceedance compared with NAA**

Green Peter reservoir (Figure 3.2-143) would fill to about the same levels or higher in the spring and then elevations would be lower in the summer and fall as compared to the NAA. These differences are driven by the integrated temperature and habitat flow regime flow targets downstream of Foster and how they differ from the BiOp flow targets.

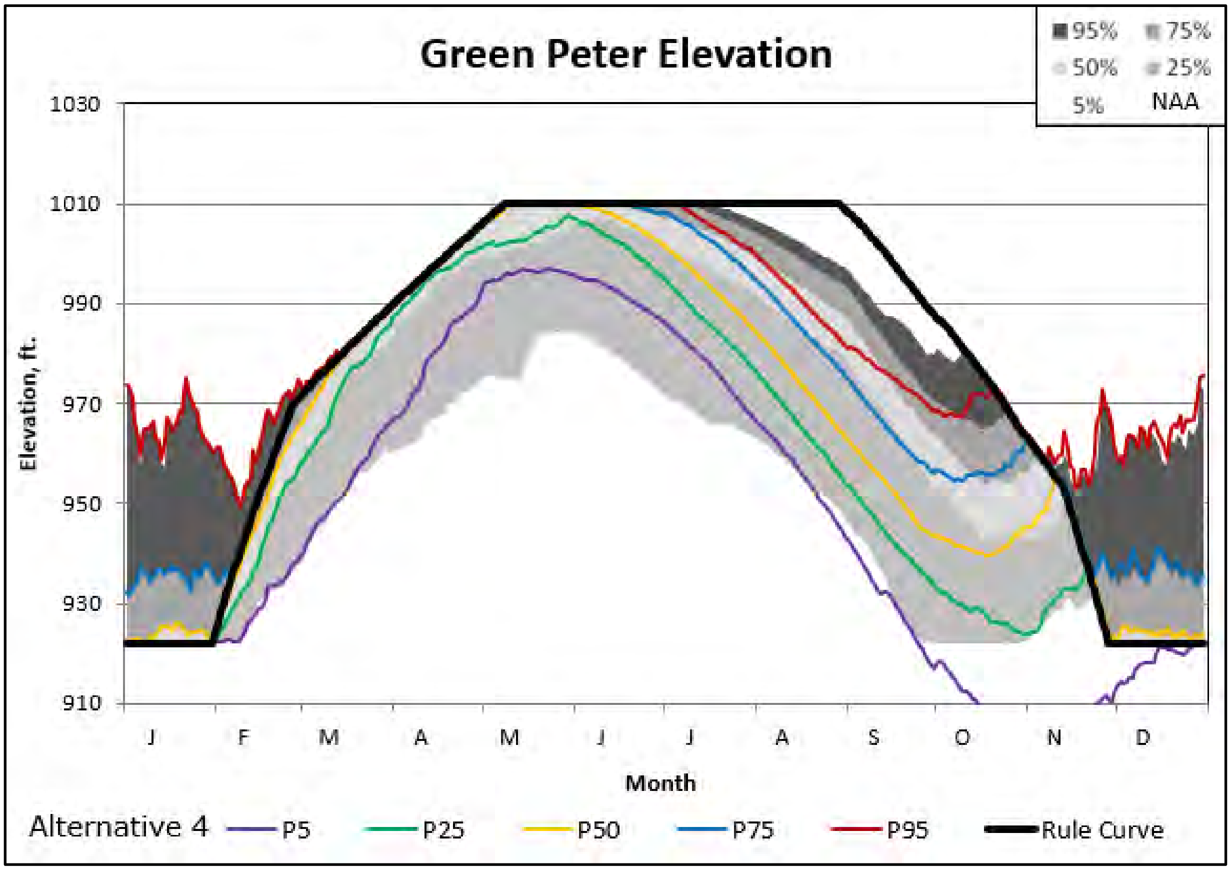



**Figure 3.2-143. Alternative 4 Green Peter water surface elevation non-exceedance compared with NAA**

The flow comparison out of Foster (Figure 3.2-144) shows the shift of water releases from spring to summer and fall in the South Santiam when compared to the NAA. The flow from the dam would meet the integrated temperature and habitat flow regime target range across the year, though this target is below the NAA 2008 BiOp target during the spring. Moving into summer, the system would meet the target range throughout the summer, whereas the NAA was unable to meet the target in October in the driest years. The lower November flows in the driest years are a result of Green Peter already being empty and drawn below minimum conservation pool in Alterative 4, when it still had water stored in the NAA.

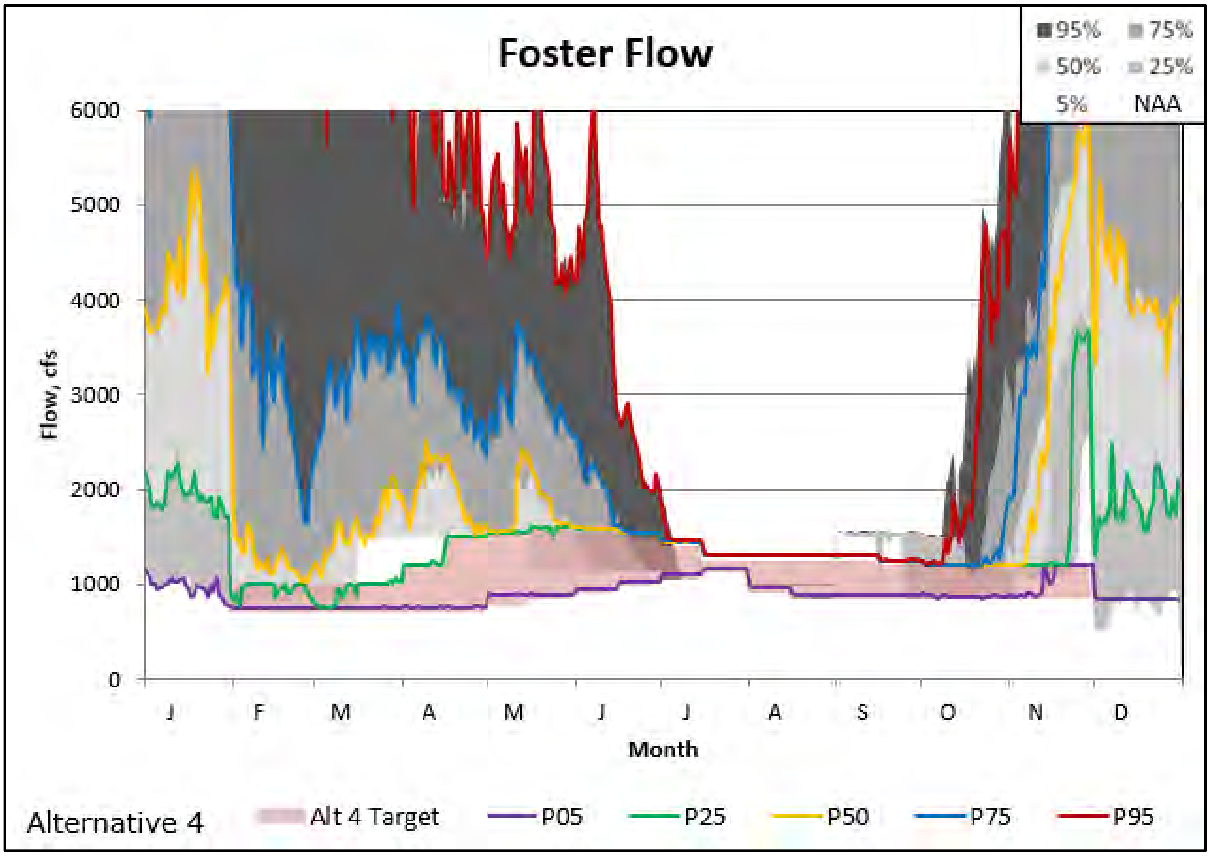



**Figure 3.2-144. Alternative 4 Foster outflow non-exceedance compared with NAA**

Although there would not be specific flow targets further downstream to the combined Santiam control point at Jefferson, the revised flow targets from upstream would be evident. The water stored during dry years from March to June would be released during the summer. Upstream summer integrated temperature and habitat flow regime targets would be higher than the NAA, so Jefferson would show higher flows in all years (Figure 3.2-145). However, the higher September NAA flows are not included in the integrated temperature and habitat flow regime, so Alternative 4 would continue the summer trends instead of bumping up as in the NAA.

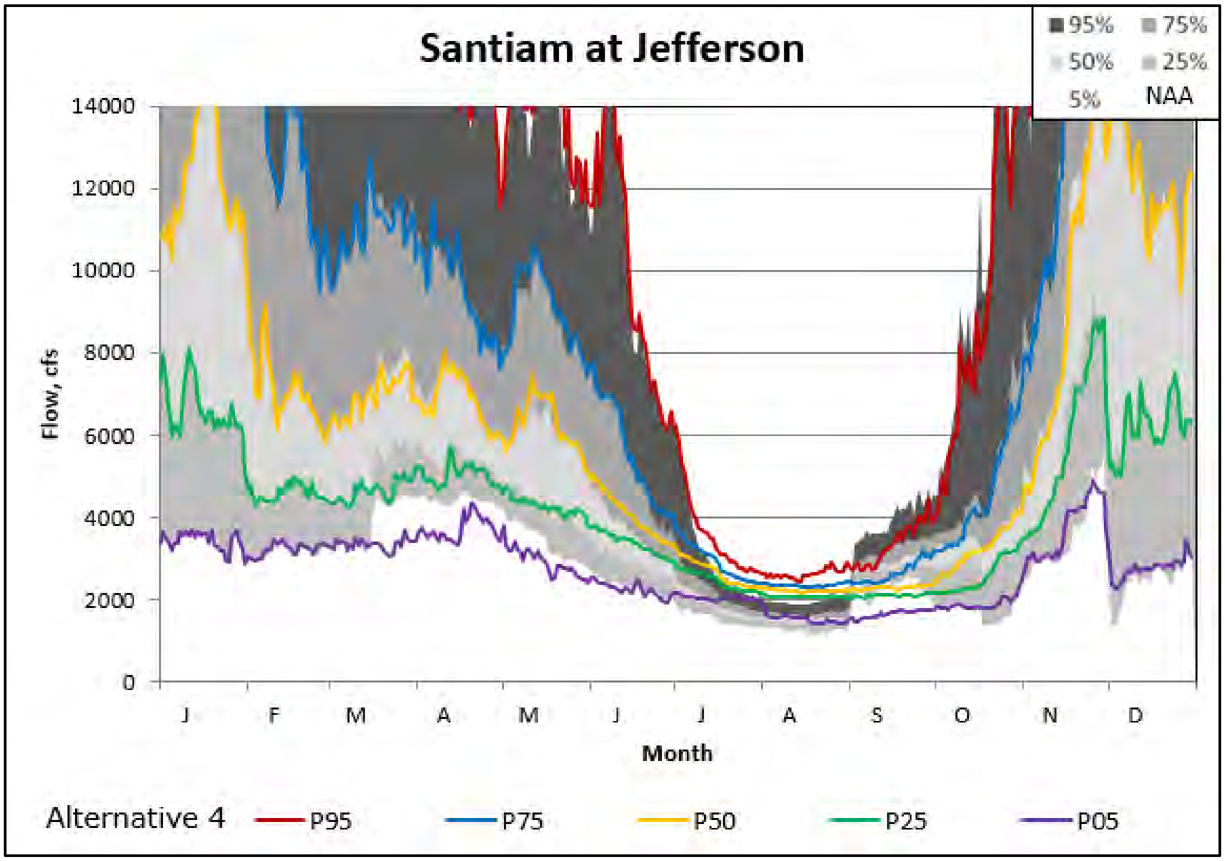



**Figure 3.2-145. Alternative 4 Santiam River at Jefferson flow non-exceedance compared with NAA**

### *3.2.2.9.2 Long Tom Subbasin*

As explained in the NAA, Fern Ridge reservoir is operated for recreation and fish and wildlife habitat in the conservation season and typically seeks to maximize the reservoir pool during the summer. Alternative 4 would not appreciably change this goal and the hydrologic patterns would be nearly the same as the NAA, as shown in Figure 3.2-146. The Alternative 4 downstream control point flows at Monroe would show a similar lack of change from the NAA.

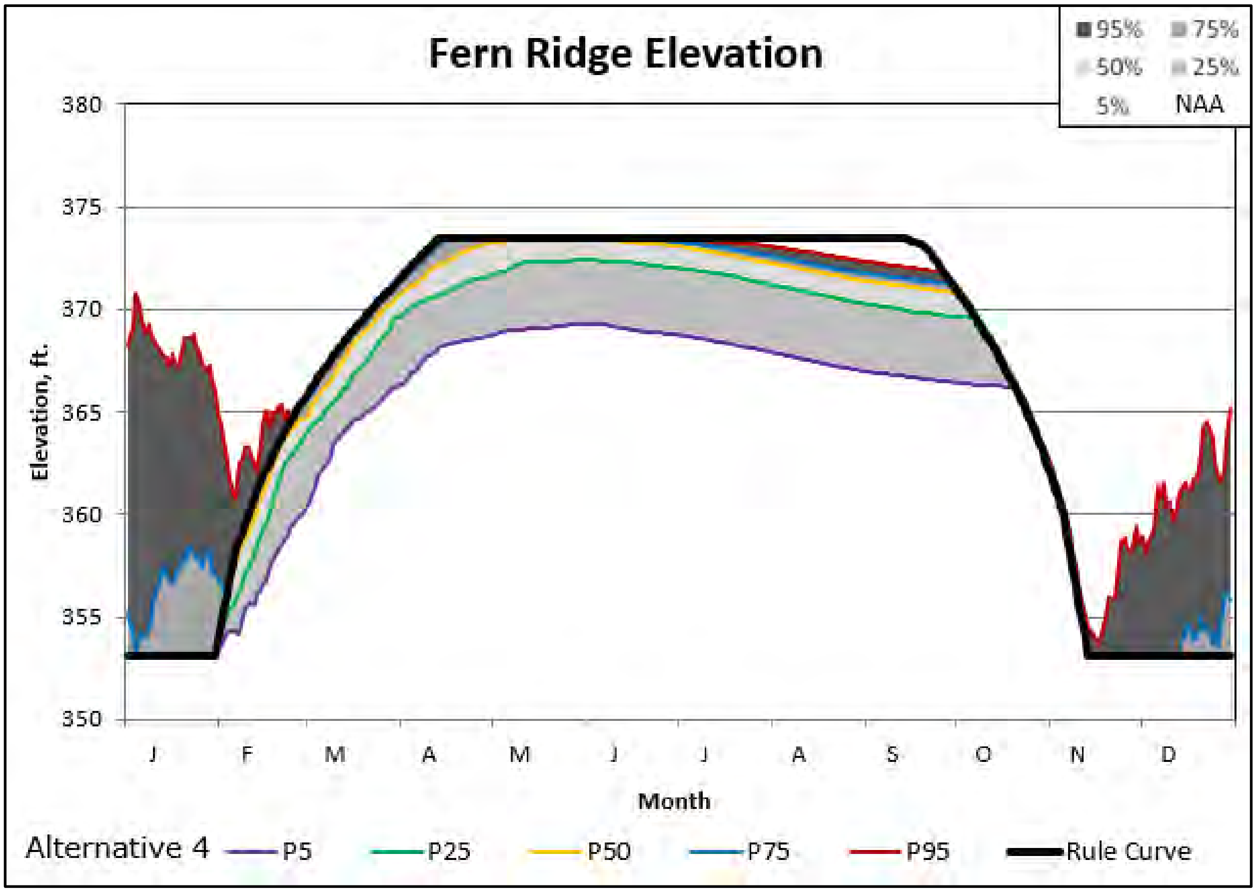



**Figure 3.2-146. Alternative 4 Fern Ridge water surface elevation non-exceedance compared with NAA**

### *3.2.2.9.3 McKenzie Subbasin*

Blue River (Figure 3.2-147) and Cougar reservoirs would fill to higher elevations in dry years due to the lower spring flow targets in the McKenzie River and Salem as compared to the NAA. Both reservoirs fill in wetter years, so there would be limited difference in everything above the P25 for the conservation season. Like Alternative 1, Alternative 4 would allow Blue River to augment instream flows by using the inactive pool below minimum conservation elevation and it would do so during drier than average Novembers.

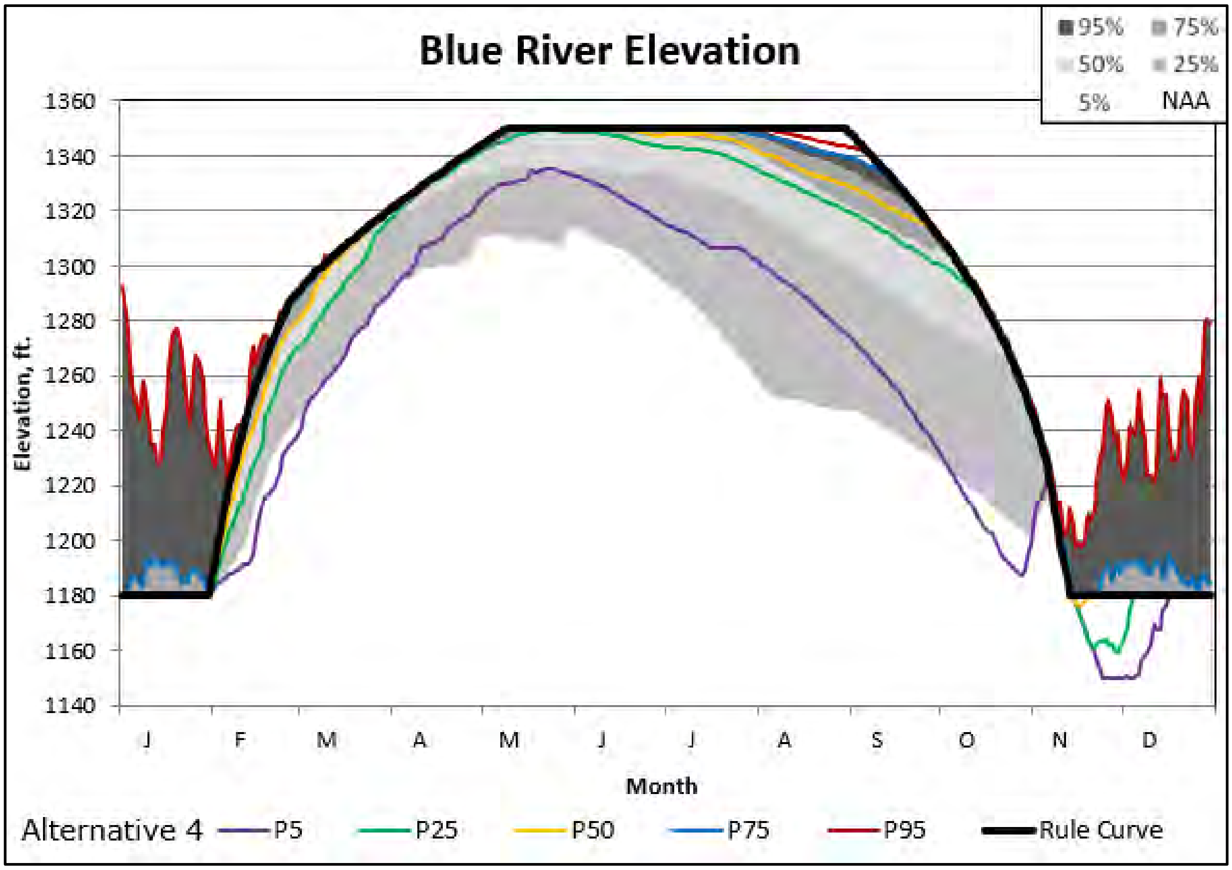



**Figure 3.2-147. Alternative 4 Blue River water surface elevation non-exceedance compared with NAA**

Cougar outflow would meet or exceed its integrated temperature and habitat flow regime target more often throughout the year than under the NAA regime, as shown in Figure 3.2-148. Like Alternative 4 targets at other locations, they would have a lower total volume, but are more variable over the year. The flow changes as compared to the NAA would be limited in wet years and have the effect of shifting flow from spring into summer and fall during dry years.

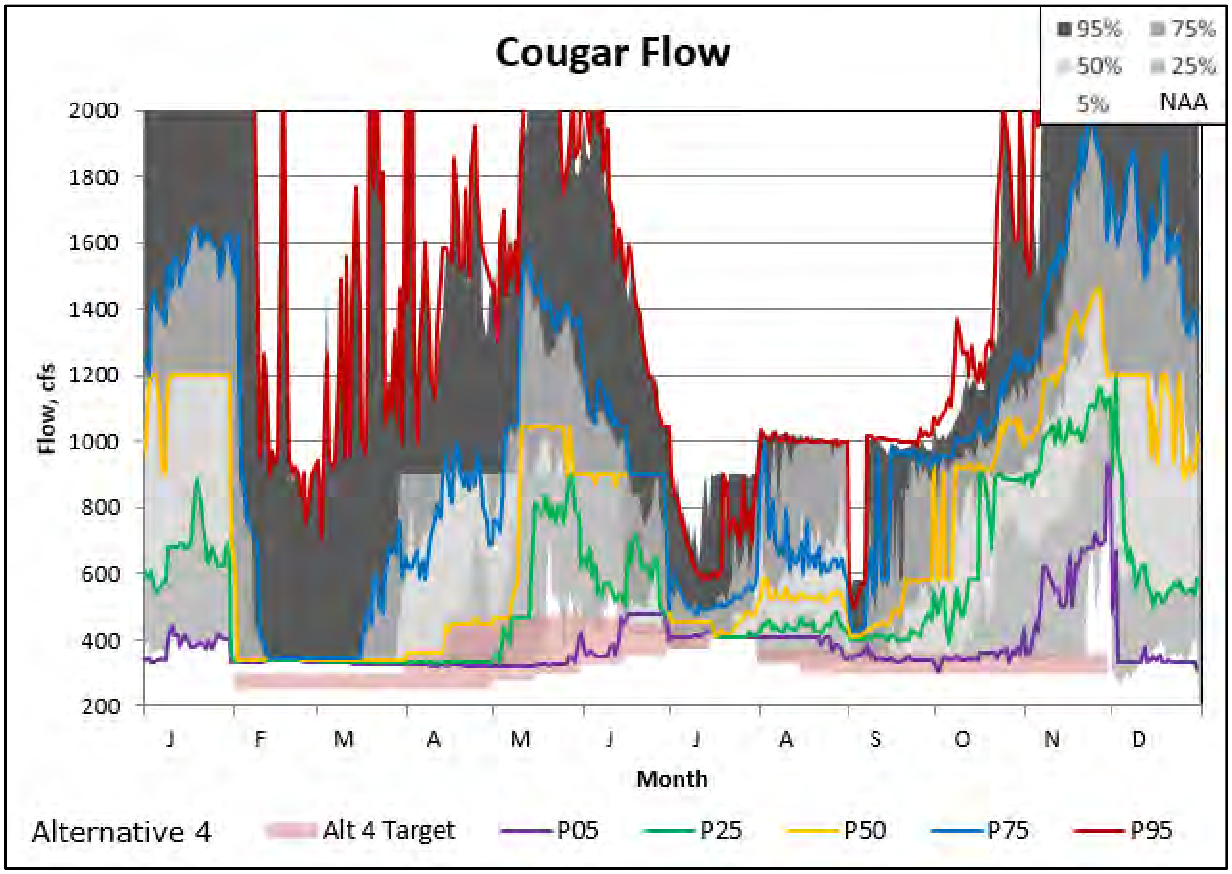



**Figure 3.2-148. Alternative 4 Cougar outflow non-exceedance compared with NAA**

The outflow chart at Cougar in Figure 3.2-148 would show high variability due to its proximity to a single dam, but Figure 3.2-149 (McKenzie at Vida) clearly shows this shift in the drier years – the P05 and P25 lines.

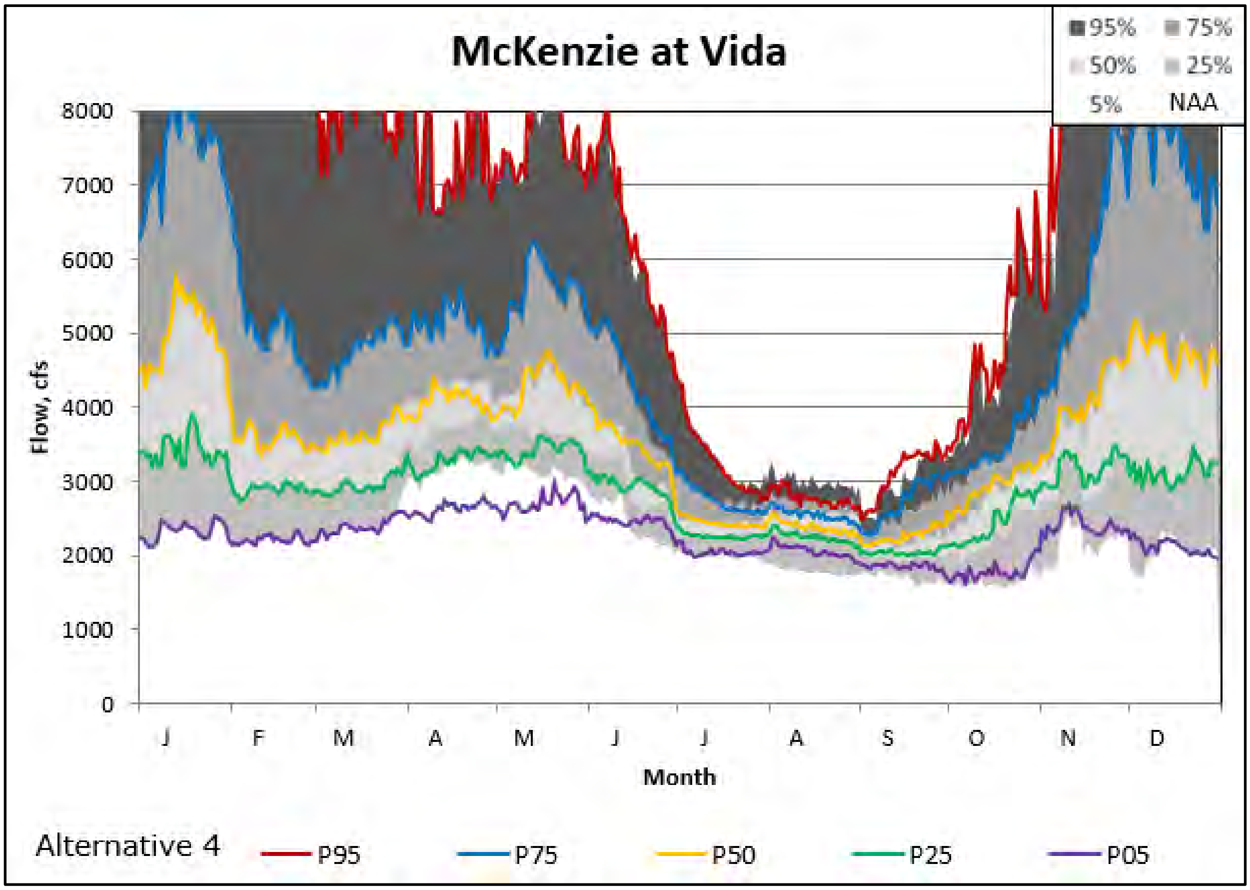



**Figure 3.2-149. Alternative 4 McKenzie River at Vida flow non-exceedance compared with NAA**

### *3.2.2.9.4 Middle Fork of the Willamette Subbasin*

As in Alternative 1, Hills Creek (Figure 3.2-150) initially would fill more quickly due to the lower downstream flow targets and would stay at similar elevations during wet years when compared to the NAA. However, the integrated temperature and habitat flow regime targets are higher than the Congressionally authorized minimum flows. Therefore, during dry years, the Hills Creek reservoir would augment instream flows by using the power pool earlier in the year to meet the flow target at Albany than compared to Alternative 1. Its capacity would be exhausted in the driest years (P05 line), at which point Lookout Point would supply additional water until it too reaches its minimum in Figure 3.2-151.

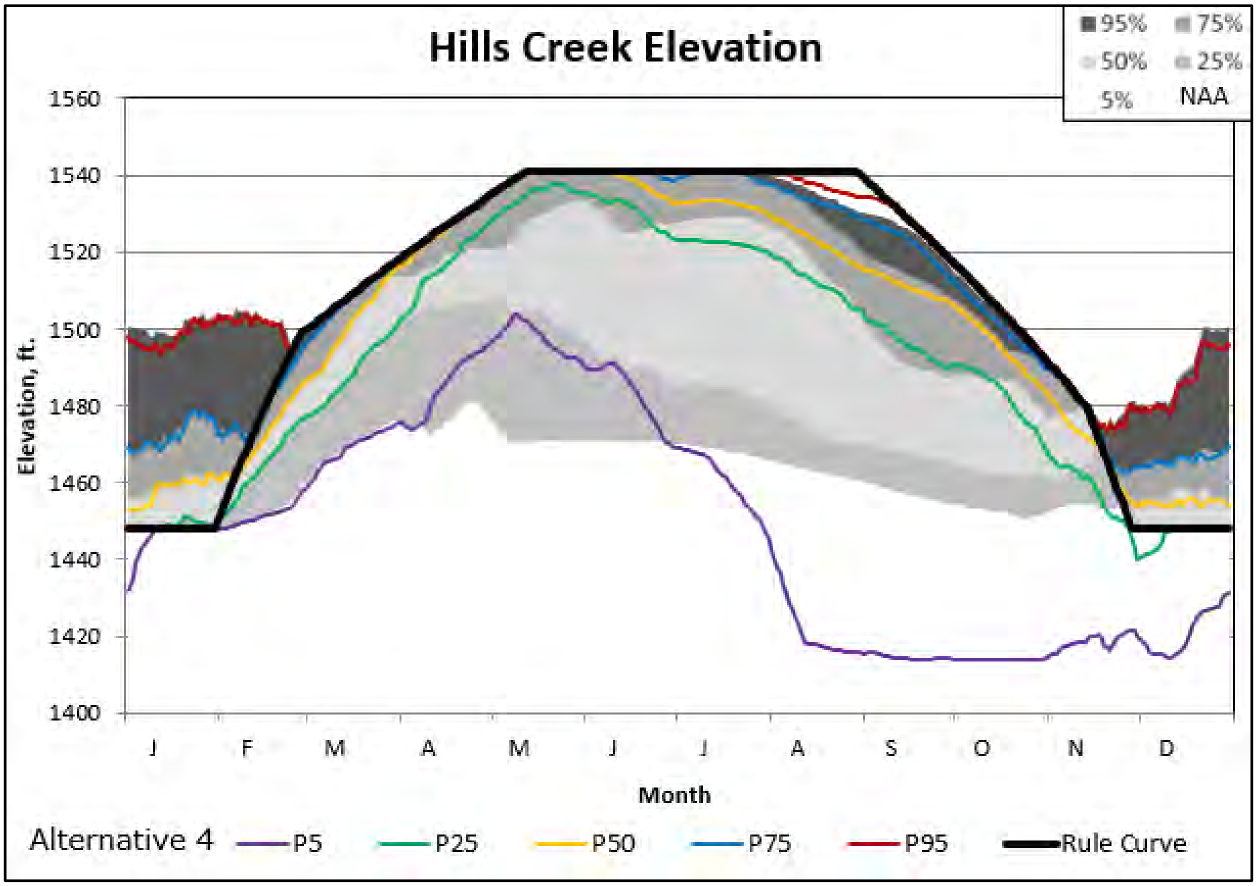



**Figure 3.2-150. Alternative 4 Hills Creek water surface elevation non-exceedance compared with NAA**

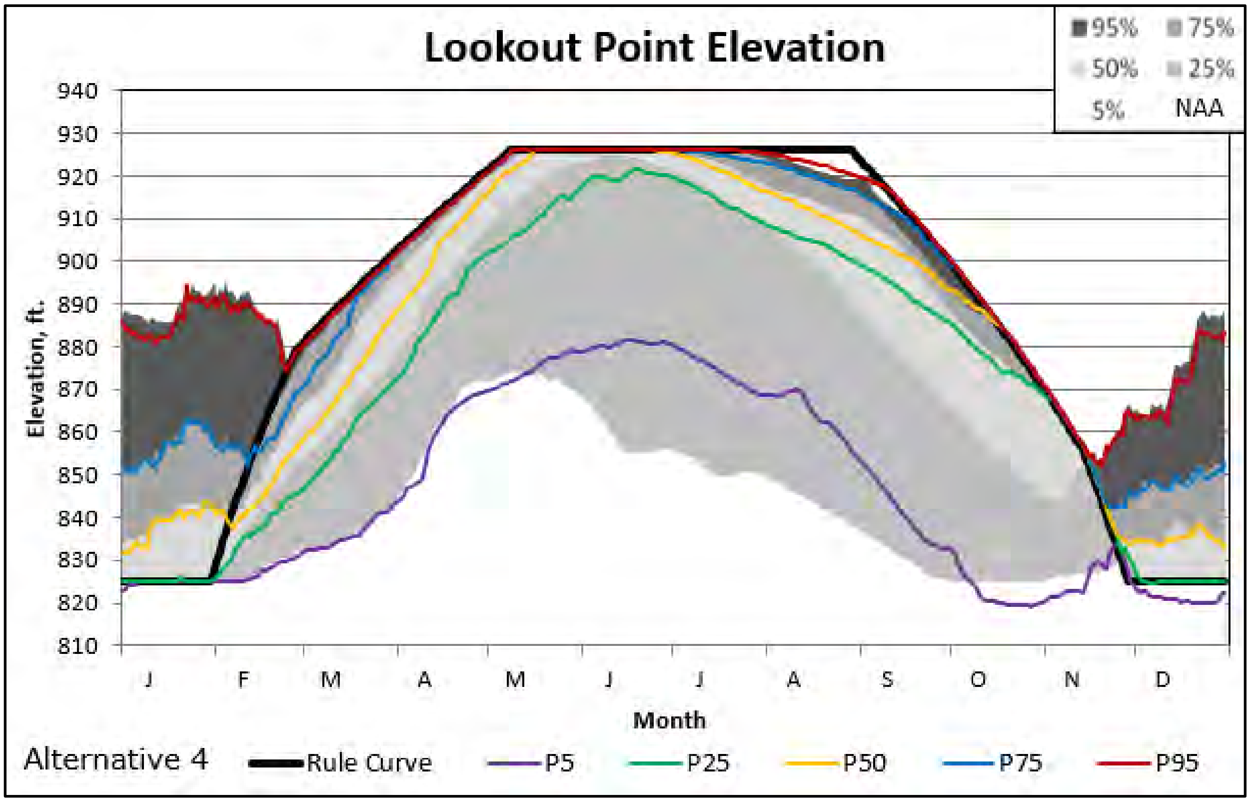



**Figure 3.2-151. Alternative 4 Lookout Point water surface elevation non-exceedance compared with NAA**

Fall Creek reservoir (Figure 3.2-152) would be able to provide some additional flow until its mid-November drawdown since water surfaces would be generally above the NAA baseline.

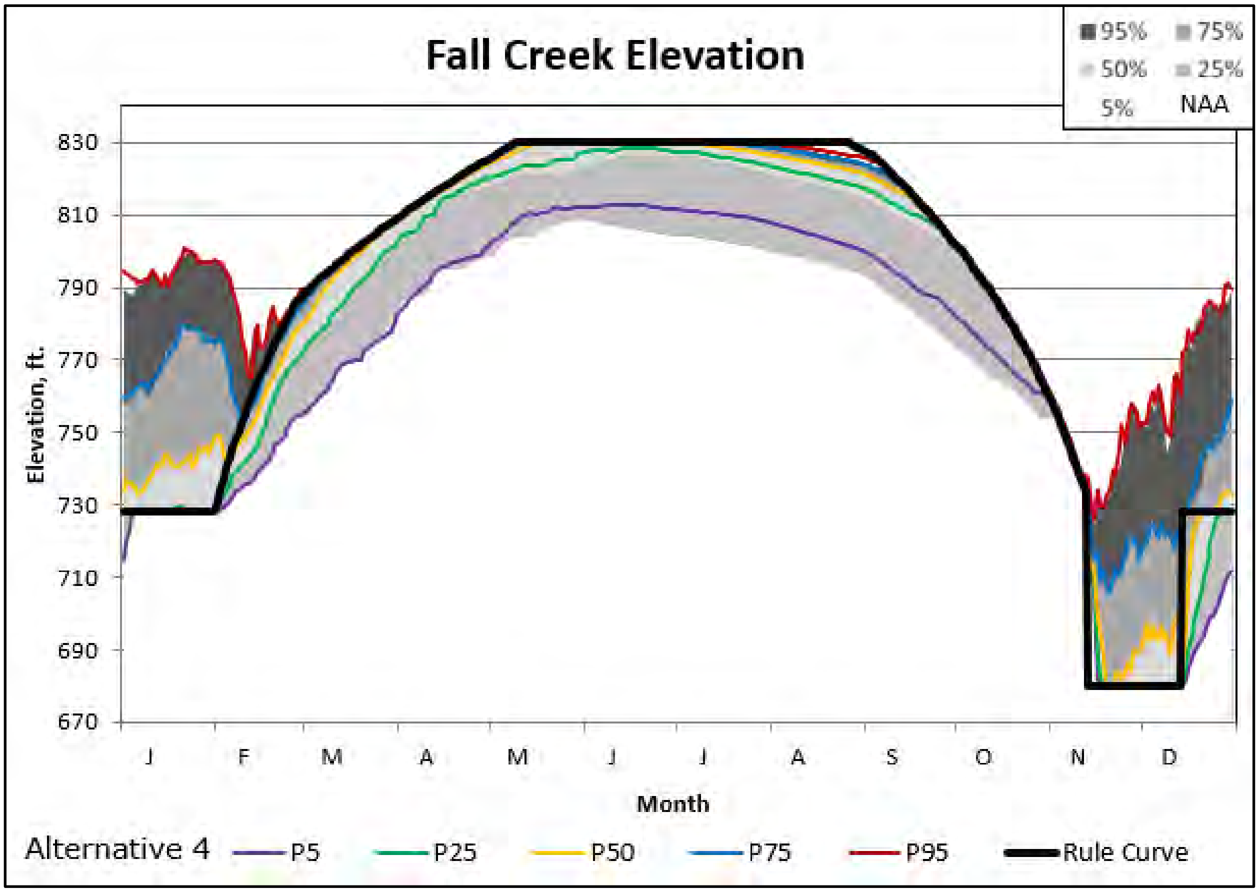



**Figure 3.2-152. Alternative 4 Fall Creek water surface elevation non-exceedance compared with NAA**

At the downstream control point at Jasper (Figure 3.2-153), the dry year water release shift would be evident, with lower flows in the spring and higher flows into the summer and fall compared to the NAA. Since reservoirs pools would usually be at higher elevations leading into flood season, additional releases in October would occur across most water years.

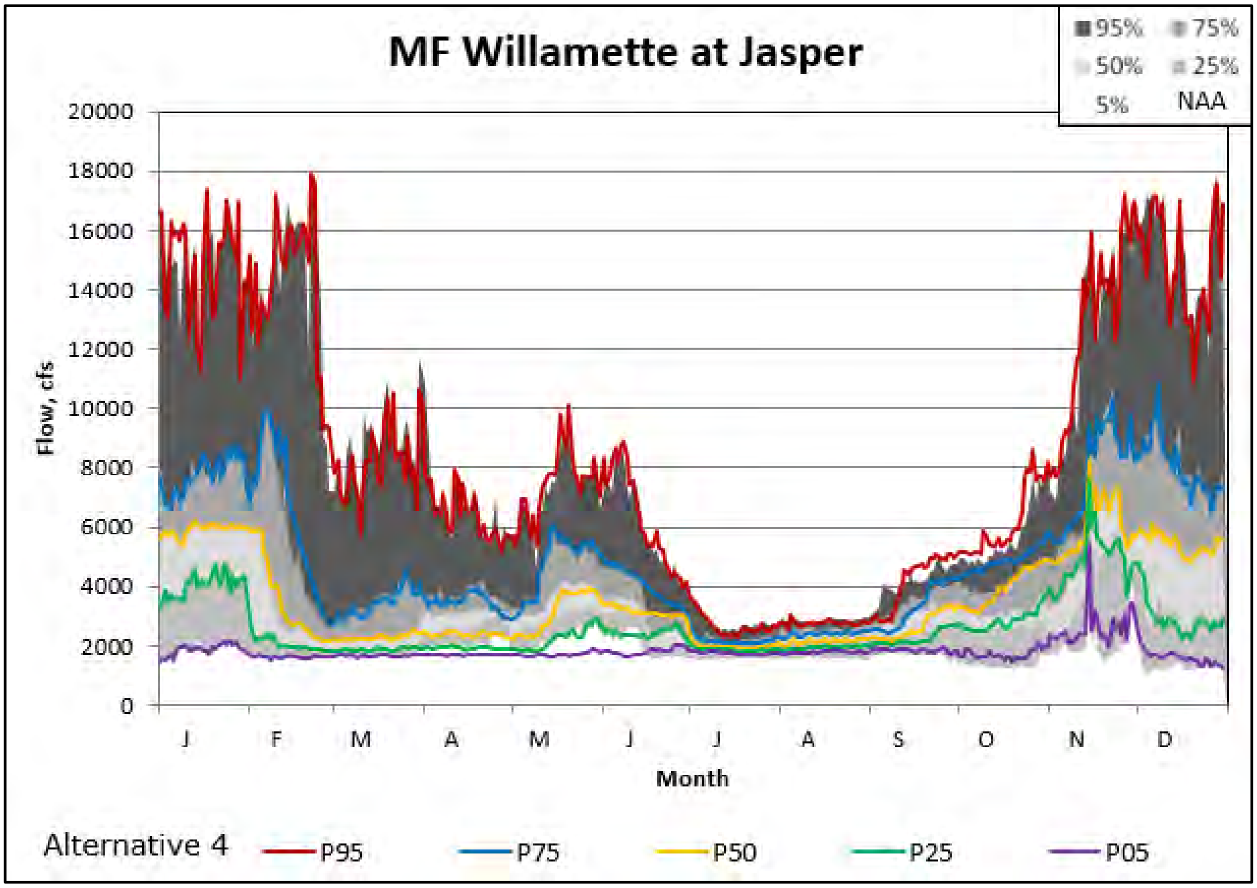



**Figure 3.2-153. Alternative 4 Middle Fork of Willamette River at Jasper flow non-exceedance compared with NAA**

### *3.2.2.9.5 Coast Fork of the Willamette Subbasin*

Dorena (Figure 3.2-154) and Cottage Grove reservoirs would fill more quickly in spring and have generally higher water surface levels throughout the conservation season as compared to the NAA, but lower as compared to Alternative 1. The integrated temperature and habitat flow regime is generally between the BiOp targets of the NAA and the Congressionally authorized minimum flows of Alternative 1. Dorena and Cottage Grove would augment instream flows by using the inactive pool in late fall more frequently than Alternative 1 as they supply water to various points downstream.

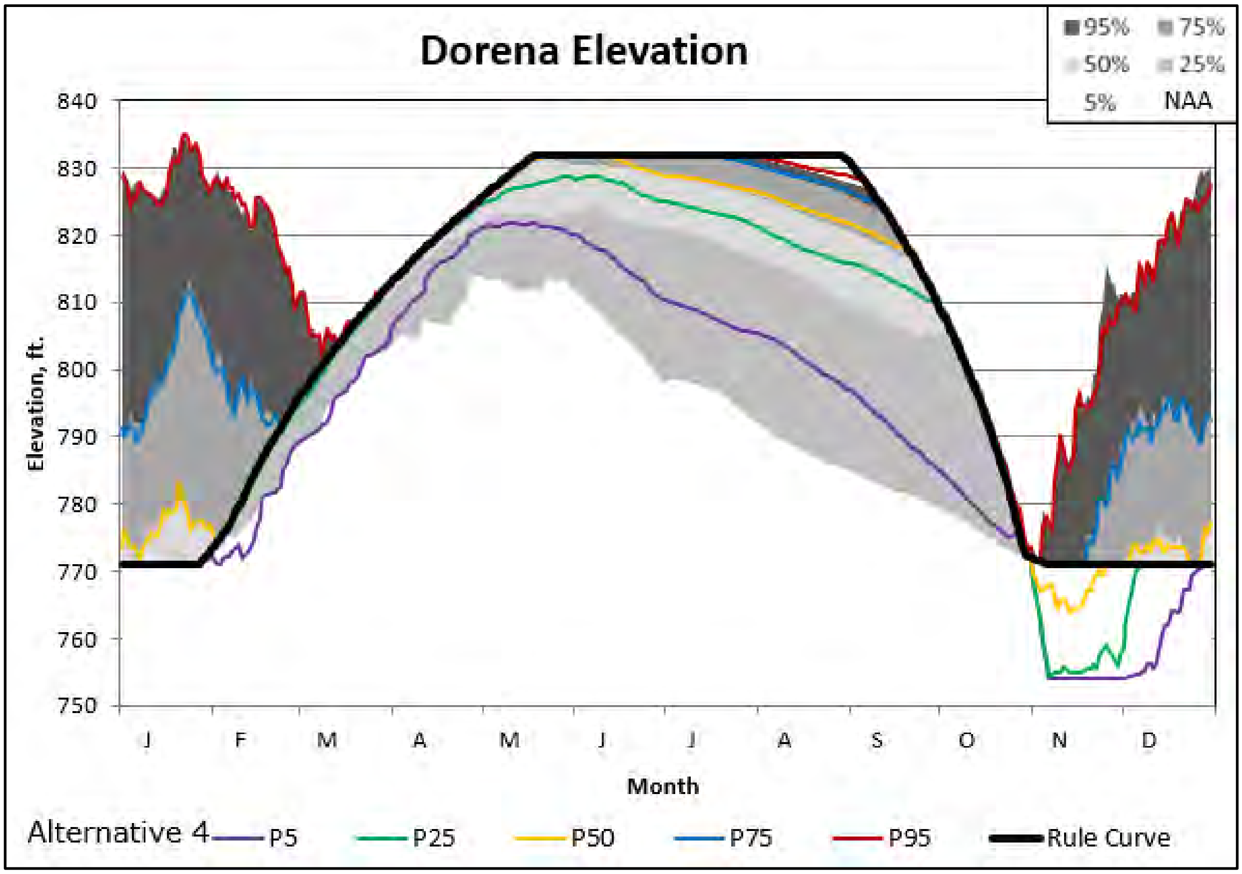



**Figure 3.2-154. Alternative 4 Dorena water surface elevation non-exceedance compared with NAA**

The control point for Dorena and Cottage Grove at Goshen (Figure 3.2-155) shows the characteristic dry-year shift of flow from spring to fall in Alternative 4. Wetter years and summer flows would remain about the same. The P05 and P25 lines at Goshen show the increased November flow using water from below minimum conservation elevation before returning to roughly the same as the NAA in December.

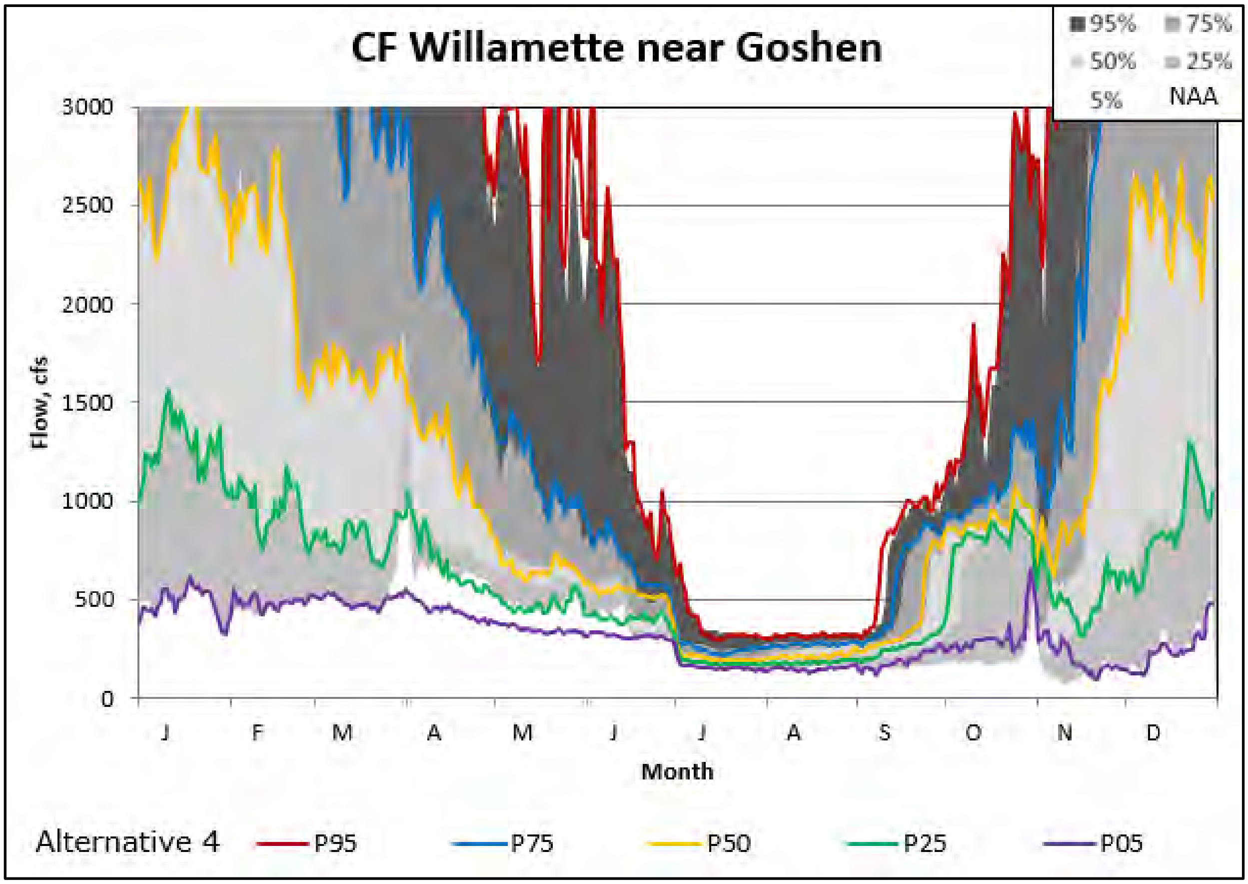



**Figure 3.2-155. Alternative 4 Coast Fork of Willamette River at Goshen flow non-exceedance compared with NAA**

### *3.2.2.9.6 Mainstem Willamette River*

Alternative 4 would alter the regulated hydrology of the mainstem Willamette River control points during the drier years most, with the largest impact to the average and wet years coming in the fall with slightly higher flows as compared to the NAA. The P05 and P25 lines are well below their NAA counterparts from April to June at Albany (Figure 3.2-156). Although the Albany August-to-October flow target is reduced as compared to the NAA (to 4,500 cfs from 5,000 cfs), flows would remain above the target much more frequently with the water stored in the spring released to augment flows in the late summer and fall.

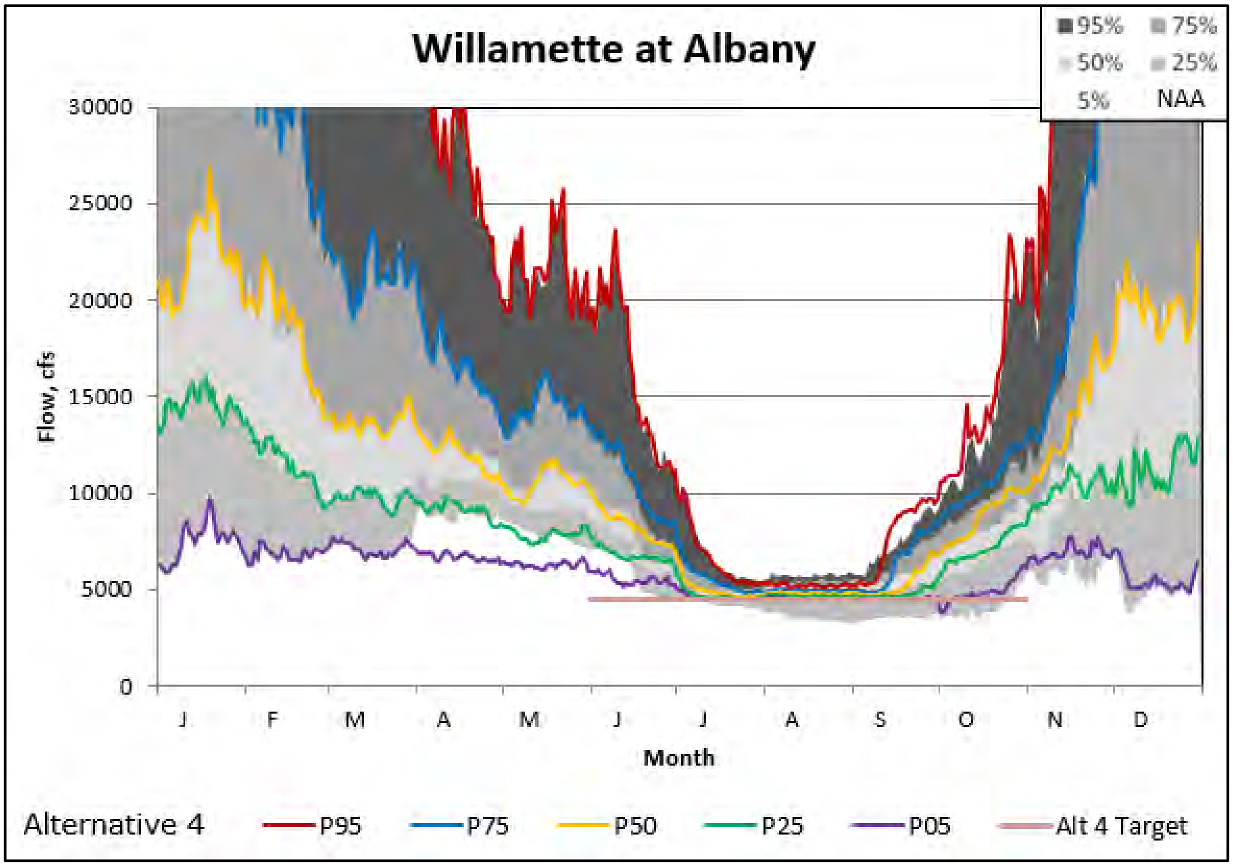



**Figure 3.2-156. Alternative 4 Willamette River at Albany flow non-exceedance compared with NAA**

The integrated temperature and habitat flow regime would alter the flow targets at Salem more than any other location as compared to the NAA. The variable target from April to June (stepped box in Figure 3.2-157) is only active during hot weather. These higher flows would be designed to maintain cooler rivers for fish survival. The hotter the weather, the higher the flow target within the bounds in the figure. If the weather is cool, the target would revert to the lower Alternative 4 baseline target of 5,000 cfs. Section 2.2.1, Flow Measures, contains a more detailed explanation of this flow target.

Since the temperatures required to activate the higher flow targets generally do not last for the entire three months, flows at Salem would be lower during dry years for Alternative 4, routinely missing the NAA 2008 BiOp target but well within the integrated temperature and habitat flow regime targets. As at other upstream locations, Alternative 4 would have higher flows in summer and fall, and would hit its flow target more frequently than the NAA.

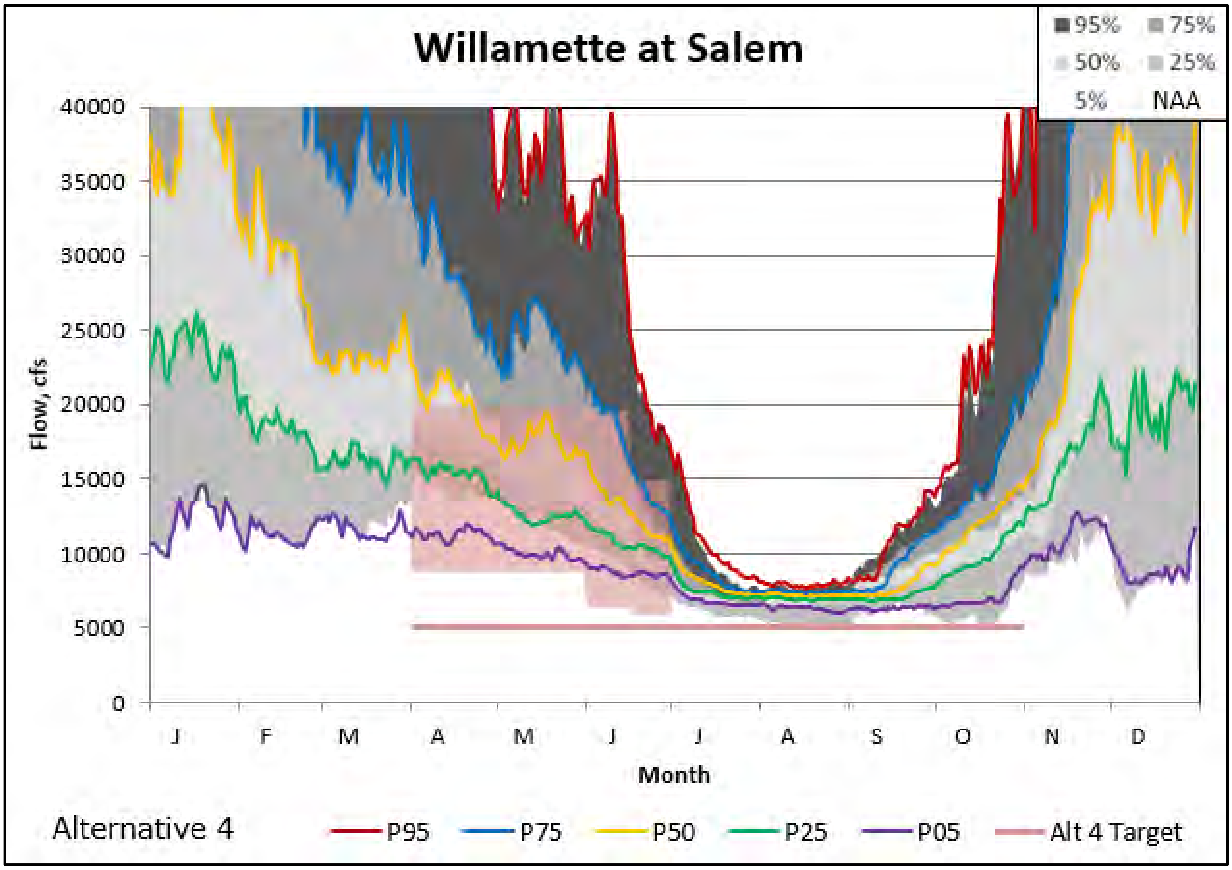



**Figure 3.2-157. Alternative 4 Willamette River at Salem flow non-exceedance compared with NAA**

Summer and fall flows across water year types would be more closely spaced than in the NAA, but this is mostly due to increased flow in the drier years. Increased flows during the wetter falls, the P50 line and above, would be due to the reservoirs preserving more storage during these years and having to release more water in preparation for winter flood season.

### *3.2.2.9.7 Near-Term Operations Measure*

See Alternative 2A, Section 3.2.2.4.7, for description of effects due to the Near-Term Operations Measure.

### *3.2.2.9.8 Climate Change*

The WVS will likely experience increasing wintertime flow volumes in the future. Some flood magnification (increased severity during flood season) is also likely. Because the WVS system storage will remain about the same, it's likely that FRM operations will face future challenges. An upward shift in median future project inflows may increase both the average reservoir water surface elevation as well as outflows downstream of the WVS dams. Reservoirs located within higher elevation subbasins, such as Detroit and Cougar, are likely to see higher rainfall and runoff volumes in the winter. Higher projected temperatures in the future will mean less snowpack than currently experienced. Lower snowpack would also reduce spring volume as the snow melts. Lower elevation subbasin projects such as Fern Ridge and Cottage Grove, with little or no snowpack, are projected to experience higher wintertime flow volumes, but similar peak runoff timing compared to historical baselines.

During conservation season, climate change will affect Alternative 4 most like Alternative 1, with the main difference being somewhat lower reservoir water surface elevations and flow in the summer of dry years. Since the Alternative 4 integrated temperature and habitat flow regime targets are lower than the NAA 2008 BiOp requirements, the reservoirs can store more water during conservation season as compared to the NAA. However, reservoirs will have to use more of this stored water to meet downstream flow targets with projected increased variability in the spring shoulder months, drier hotter summers, and lower summer baseflow. Therefore, reservoirs are projected to have lower water surface elevations compared to the NAA. Reservoirs in Alternative 4 sometimes reach minimum elevation during the summer, but less often than the NAA, meaning they would be able to augment summer flows for longer than the NAA even with projected declines in late spring and summer flows. The lowest reservoir water surface elevations will occur in the driest years, which would be drier than the WVS currently encounters, as the reservoirs are drafted more to meet downstream flow targets. The WVS would miss the mainstem Willamette flow targets more often than in Alternative 1, but much less often than the NAA. Climate change effects, and potential implications as discussed above, draw on the climate change projection and trend information provided in the climate change appendices (F1 and F2).

##### *3.2.2.10 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 5 would shift stored water releases from the spring to the summer and fall in the driest years by reducing spring mainstem and key tributary targets which would increase the likelihood that stored water would be available to meet minimum flow targets later in the conservation use season as compared to the NAA.

Foster, Detroit, and Lookout Point would have tributary targets higher than the NAA 2008 BiOp targets when reservoirs are more than 90 percent full and lower than the NAA when reservoirs are less than 90 percent full, increasing spring storage in dry years relative to the NAA and providing more storage to call on in dry summers.

Spring flow targets at Salem would be lower than BiOp dry year targets in years when water supply forecasted flows at Salem are projected to be less than 80 percent of normal under the refined integrated temperature and habitat flow regime targets. This would provide additional spring storage in dry years allowing for targets that closely resemble NAA flow targets to be met in dry summers. Additional minimum flow targets based on the air temperature at Salem release additional water when needed to keep the river, and fish in it, cool.

Alternative 5 would shift releases from April through June to July through October. Flow targets July through October would be met more frequently due to the additional accumulated stored water. Lower releases in dry springs would result in higher reservoir elevations in most reservoirs throughout the conservation season which does not occur under the NAA.

Cougar and Green Peter reservoirs have drawdowns in Alternative 5. Flow releases required to meet drawdown targets result in higher tributary and mainstem flows, particularly in the fall compared to the NAA.

Since the spring reservoir drawdown at Cougar occurs during the NAA refill period, storage at Cougar would be reduced. Refill is not initiated until June 15th after most of the reliable spring rain has fallen. As a result of the reduced storage, Cougar would not be able to release more than inflow for portions of the conservation season. The reduced storage means that other WVS reservoirs, notably in the Middle Fork of the Willamette River subbasin, would be required to release additional water to meet mainstem Willamette River flow targets.

Although there are structural actions in Alternative 5 at the WVS dams to aid fish survival, many of these do not affect the flow out of any WVS dam. These do not appear in the reservoir flow model. An example of this is the WTC tower at Detroit, which allows for greater control of the temperature of the water released from the dam but does not alter the flowrate or outlet used for dam operations. A more detailed analysis of Alternative 5 by subbasin follows.

Lower spring flows in dry years and higher summer flows in nearly all years would have long term effects on the WRB. Effects from Alternative 5 to hydrologic processes: Major as compared to the NAA.

#### *3.2.2.10.1 Santiam Subbasin*

Alternative 5 would fill Detroit reservoir more often and narrow the range of reservoir elevations prior to drafting the reservoir for flood season (Figure 3.2-158). The lower tier of the refined integrated temperature and habitat flow regime target requires lower flows downstream of Detroit in years when the reservoir would not fill in the NAA. As a result, more flow would be released later in the conservation season in the driest years and the probability of only being able to pass inflow in extremely dry, low baseflow years is lower than in the NAA.

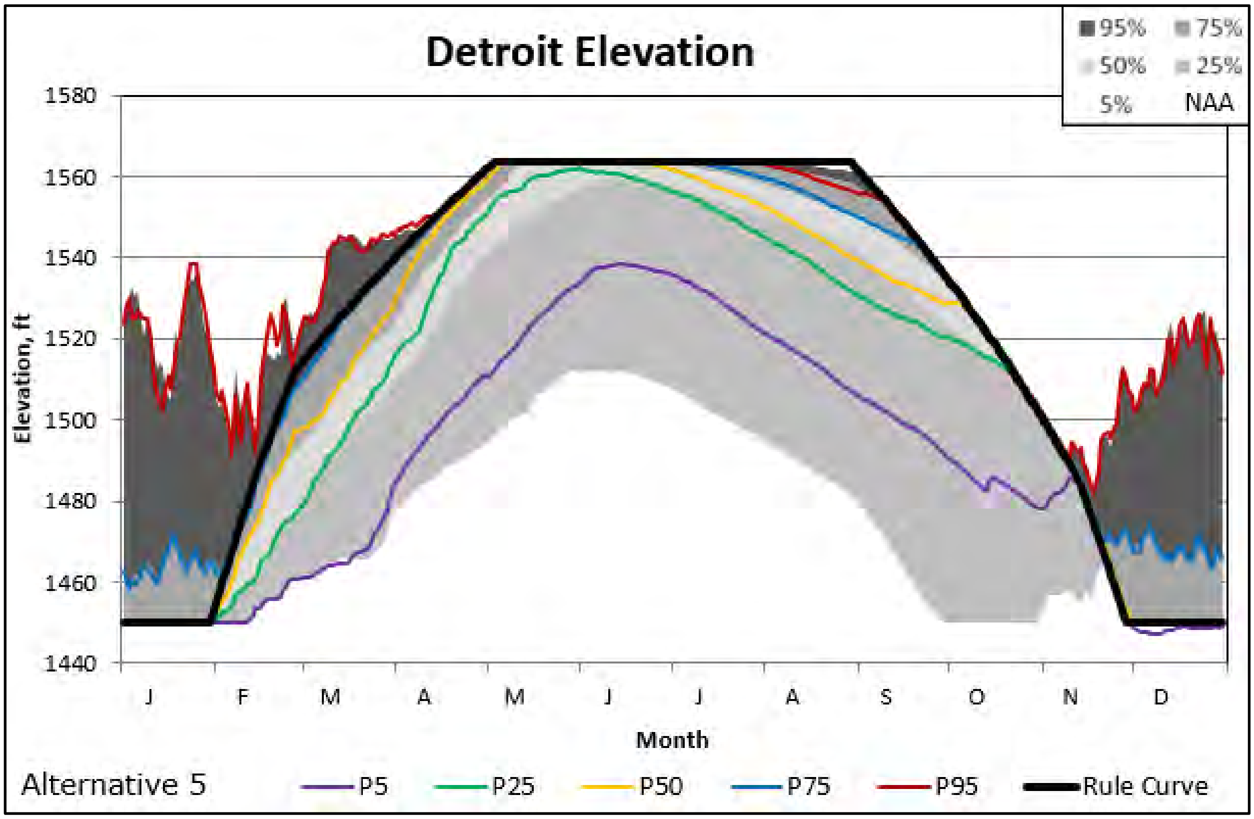



**Figure 3.2-158. Alternative 5 Detroit water surface elevation non-exceedance compared with NAA**

Green Peter reservoir (Figure 3.2-159) targets 35 feet over the regulating outlet in the fall to promote volitional fish passage. Occasionally, this would result in Green Peter beginning the conservation refill season at a lower elevation than in the NAA. Drawing down to the regulating outlet would be most likely in years with dry summers when the reservoir does not fill, and deeper fall reservoir drawdowns of longer duration would be most likely in years with dry late fall and early winter seasons.

Outflow from Foster Dam and the refined integrated temperature and habitat flow regime targets are shown in Figure 3.2-160. Variable flow targets in the spring target would lower minimum flows when Green Peter is less than 90 percent full, resulting in higher conservation season storage in dry years. A summer and fall flow target of 1200 cfs is the same in all years. Higher releases from Foster in the fall are a result of the Green Peter deeper fall reservoir drawdown.

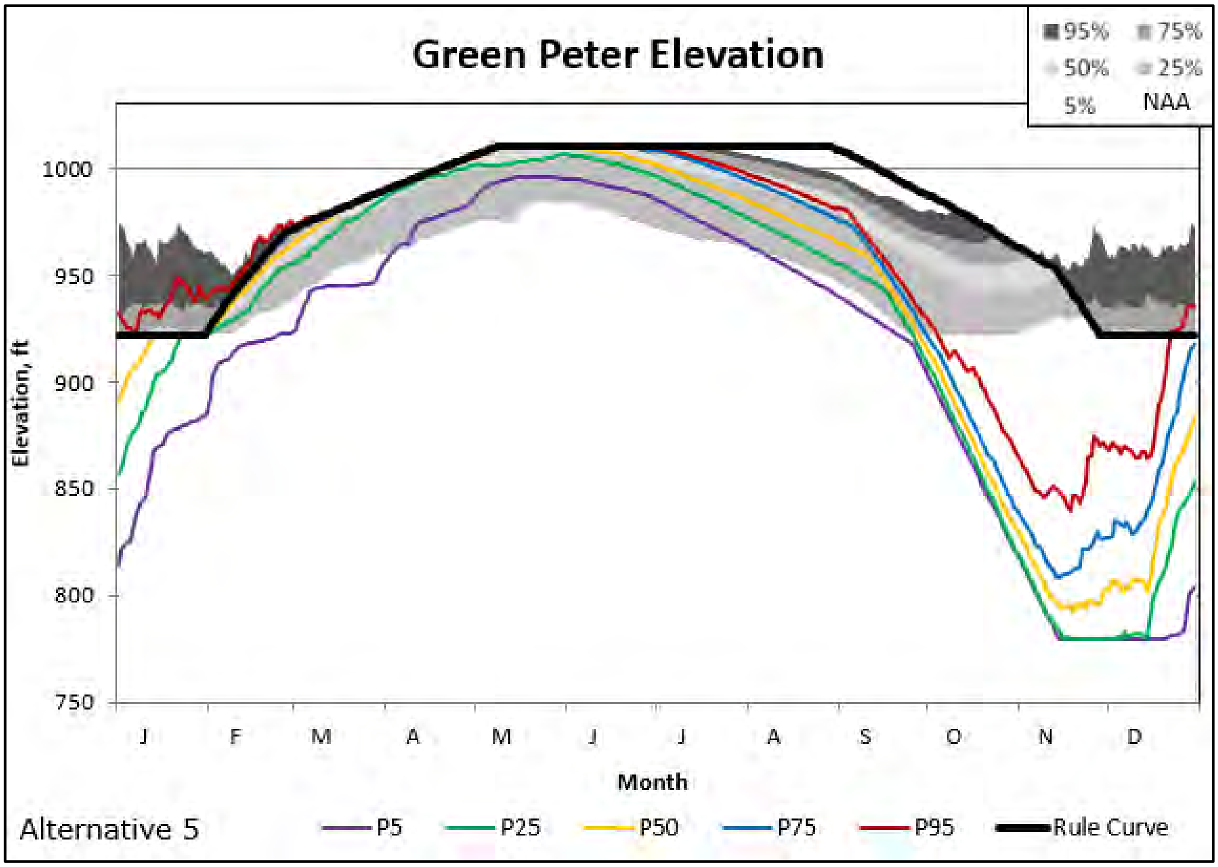



**Figure 3.2-159. Alternative 5 Green Peter water surface elevation non-exceedance compared with NAA**

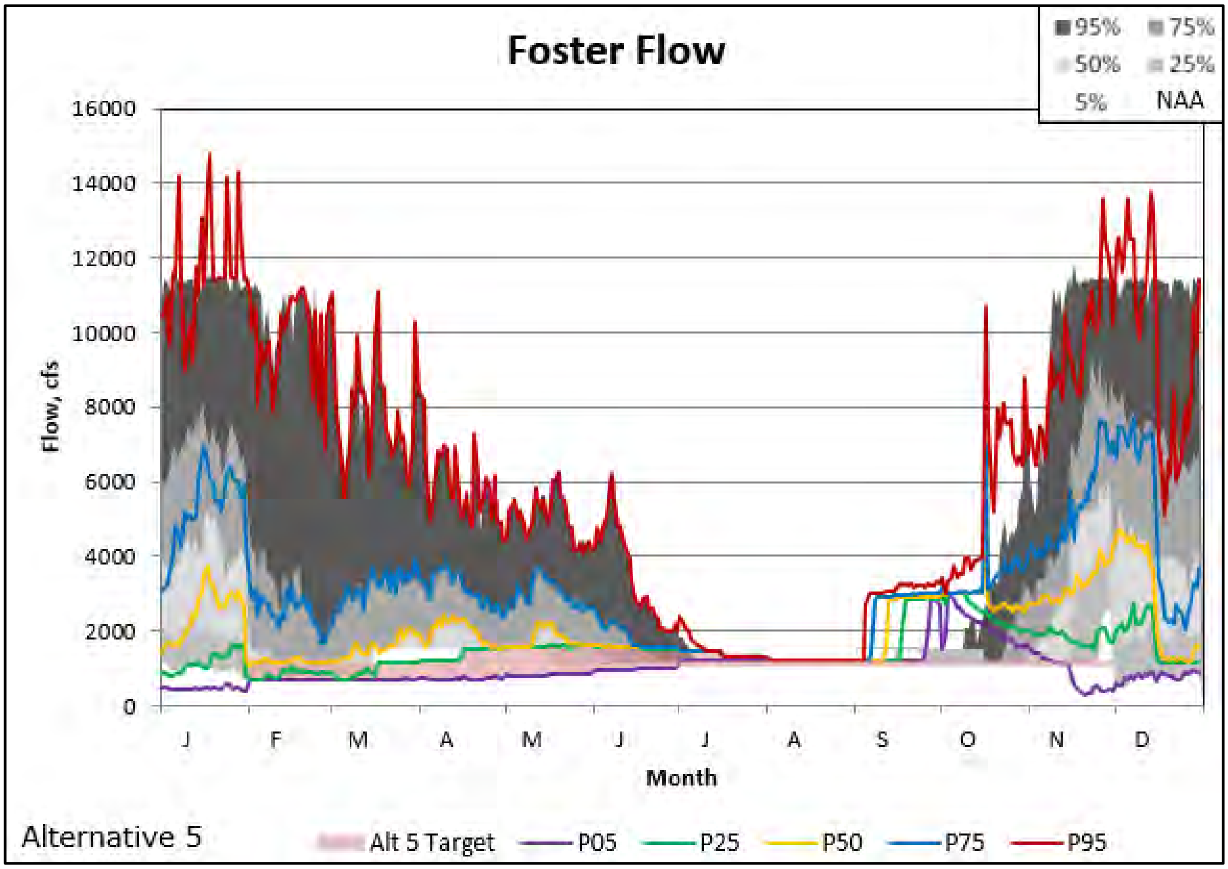



**Figure 3.2-160. Alternative 5 Foster flow non-exceedance compared with NAA**

The Santiam at Jefferson (Figure 3.2-161) shows some of the flow changes resulting from releases at Foster. Lower minimum flow targets would control the outflow from Green Peter from March through June in dry years. Higher outflows would be observed in September when Green Peter draws down for the volitional fish passage operation, while remaining below bankfull. Late fall outflows would typically be lower when Green Peter is refilling after the deeper fall reservoir drawdown as compared to the NAA

Lower flows resulting from lower flow targets in dry years in the spring would be observed at Jefferson (Figure 3.2-161). Additional reservoir storage would enable higher flows than the NAA at Jefferson beginning in July even though combined minimum flow targets below Detroit and Green Peter are slightly lower than in the NAA.

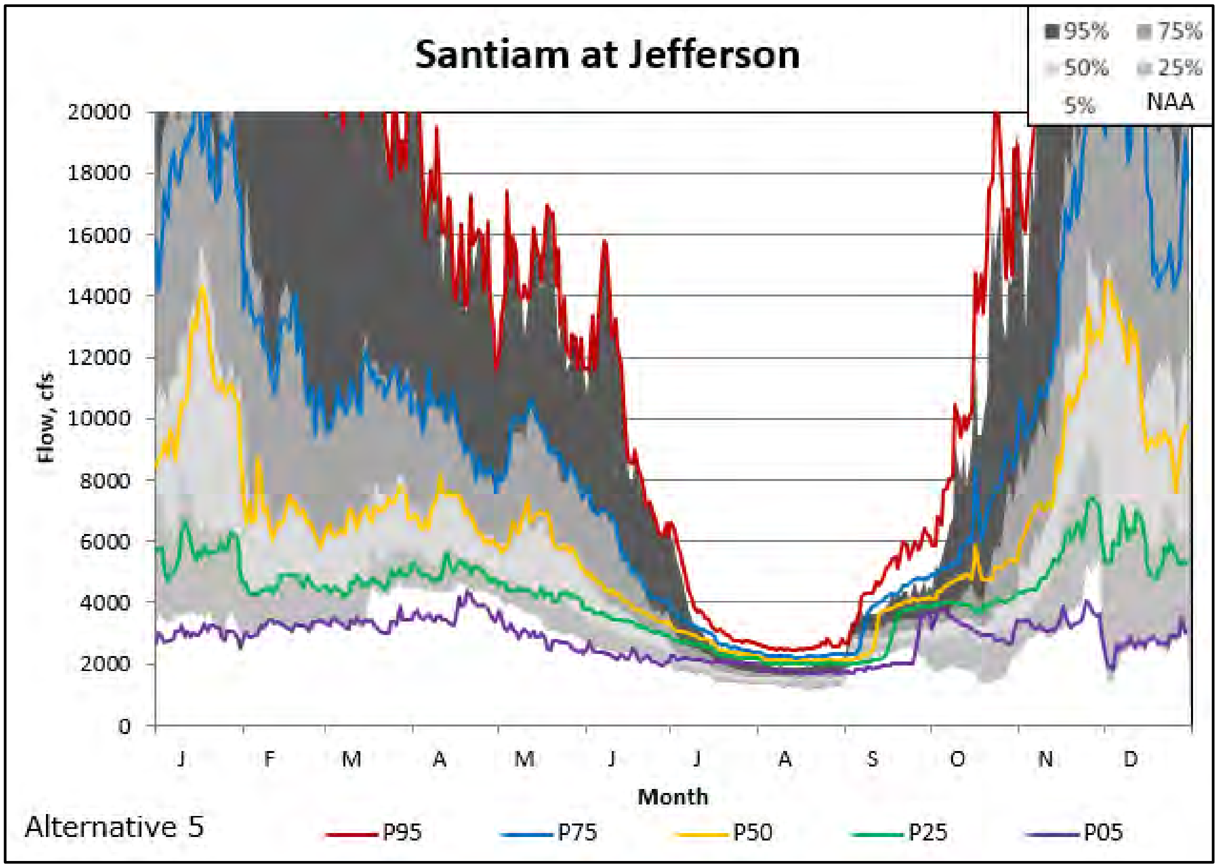



**Figure 3.2-161. Alternative 5 Santiam at Jefferson flow non-exceedance compared with NAA**

### *3.2.2.10.2 Long Tom Subbasin*

As explained in the NAA, Fern Ridge reservoir (Figure 3.2-162) is operated for recreation and fish and wildlife habitat in the conservation season and typically seeks to maximize the reservoir pool during the summer. Since Fern Ridge has a large surface area and small volume compared to the other WVS reservoirs, there is limited scope to change its operation and the water surface elevations within Fern Ridge would remain nearly the same as the NAA. Downstream flows at Monroe would remain similarly unchanged for Alternative 5.

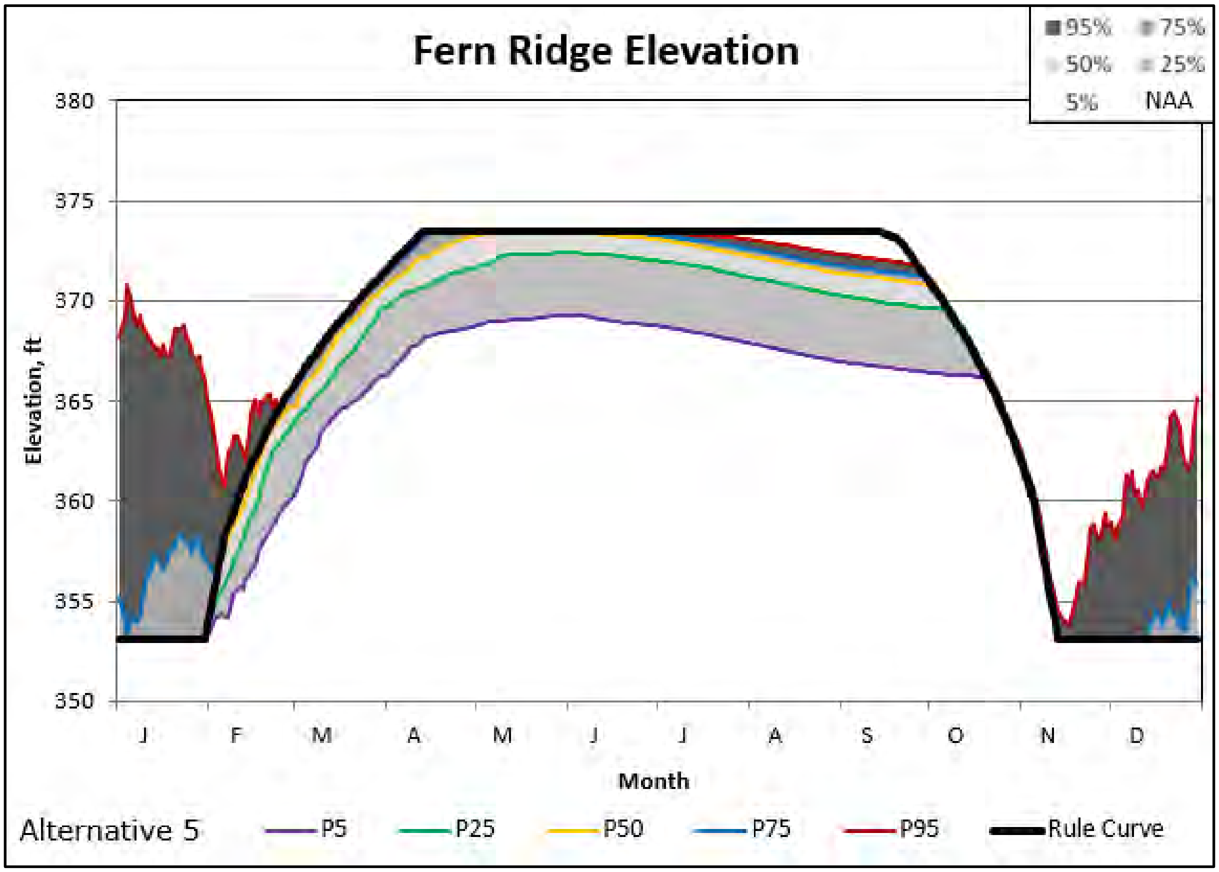



**Figure 3.2-162. Alternative 5 Fern Ridge water surface elevation non-exceedance compared with NAA**

### *3.2.2.10.3 McKenzie Subbasin*

Cougar reservoir (Figure 3.2-163) would have both spring and fall reservoir drawdowns in Alternative 5, down to 1330 feet. Conservation season refill is delayed until June 15th after all of the season's reliable rain has fallen. The reservoir water surface elevation would only rise above minimum conservation pool at the end of winter and only the wettest summers.

Spring reservoir drawdowns would reach target elevations in drier than average conditions and deeper fall reservoir drawdowns are most likely to occur in years with lower-than-average conservation season refill. Cougar would release well below the NAA tributary target of 300 cfs for long durations as a result of the drawdowns.

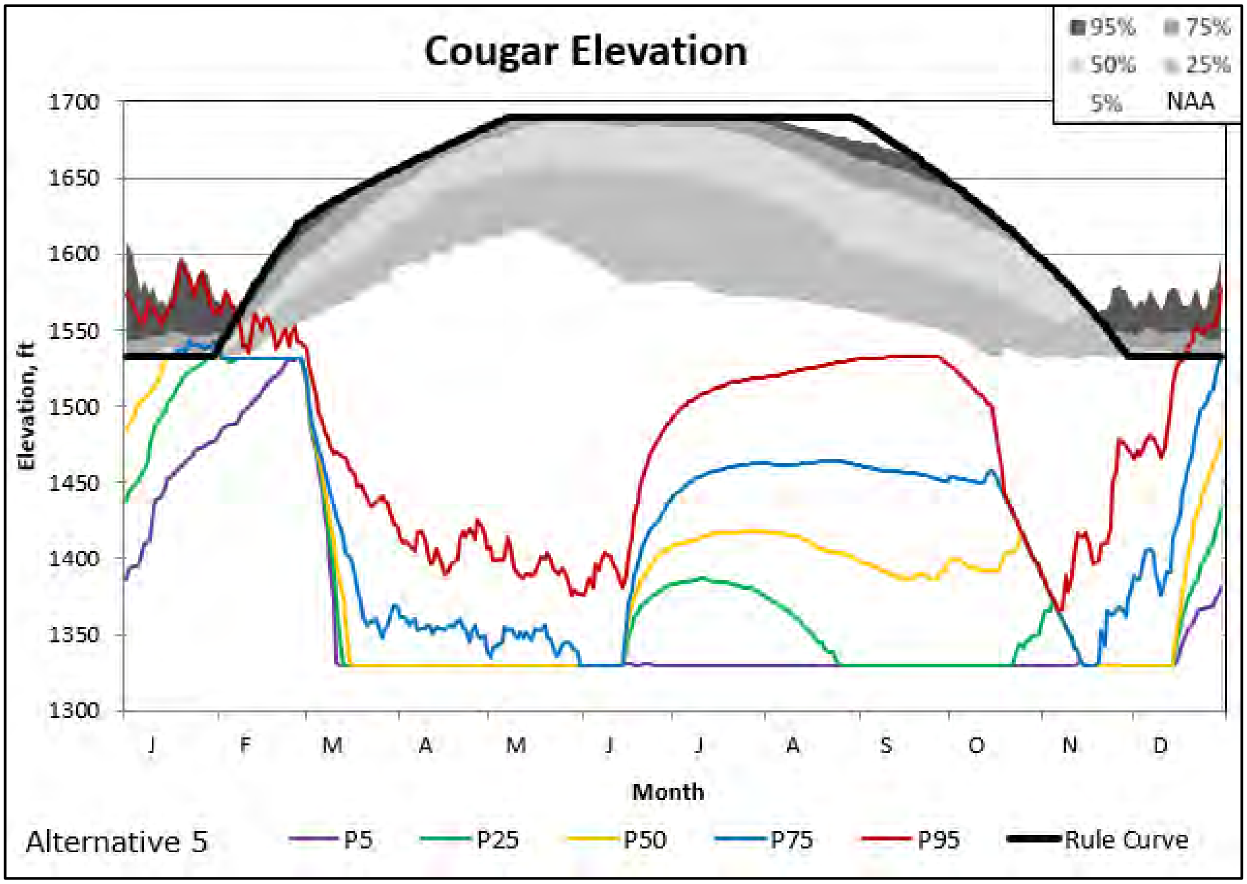



**Figure 3.2-163. Alternative 5 Cougar water surface elevation non-exceedance compared with NAA**

Blue River reservoir (Figure 3.2-164) would fill more often as compared to the NAA and uses the inactive pool to supplement downstream flow targets during October in the driest years. Blue River would be required to store more water during very wet years for the McKenzie River at Vida to remain at or below bankfull since Cougar is drafting for the spring reservoir drawdown. Additionally, Blue River would augment instream flows by using the inactive pool during the fall of very dry years to make up for the low releases from Cougar.

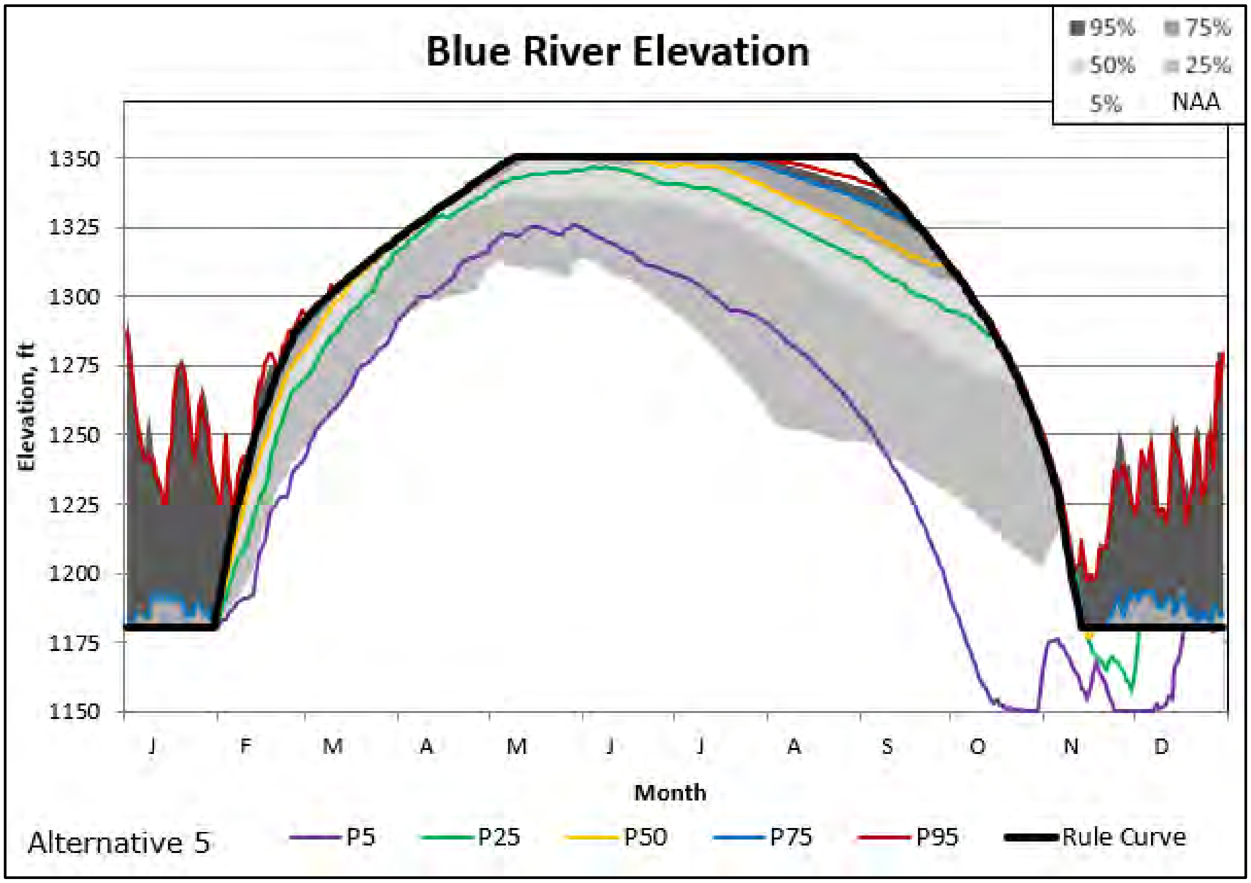



**Figure 3.2-164. Alternative 5 Blue River water surface elevation non-exceedance compared with NAA**

Moving downstream to the control point for both Cougar and Blue River, the McKenzie River at Vida (Figure 3.2-165) would show the effect of the Cougar drawdowns as compared to NAA. The higher flows in the spring would result from Cougar's releases to reach spring reservoir drawdown elevation. Lower flows starting in June would be the result of Cougar having reduced storage throughout the conservation season. Blue River would be capable of making up some of the shortfall in releases from Cougar.

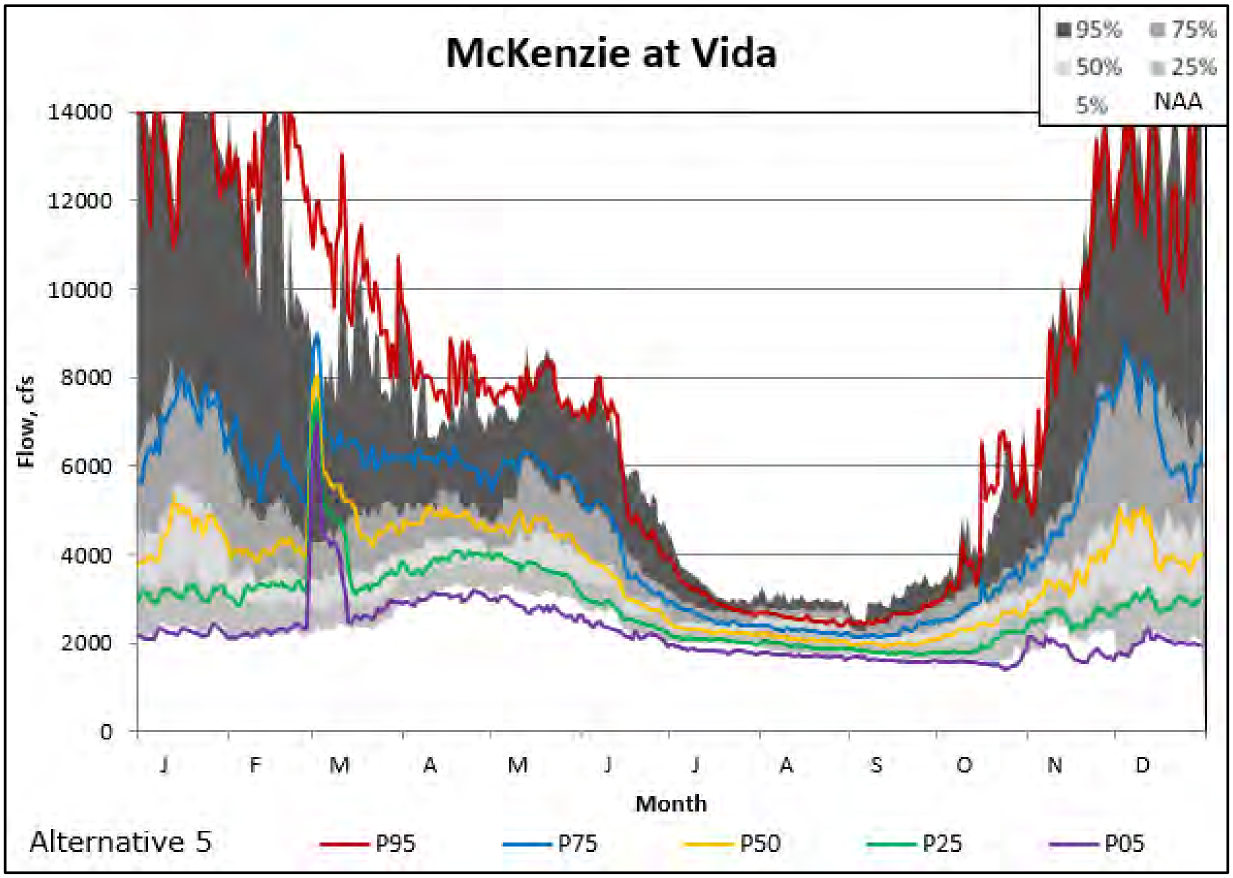



**Figure 3.2-165. Alternative 5 McKenzie River at Vida flow non-exceedance compared with NAA**

### *3.2.2.10.4 Middle Fork of the Willamette Subbasin*

Hills Creek (Figure 3.2-166) initially would fill more quickly due to the lower refined integrated temperature and habitat flow regime targets and would stay at similar or higher elevations during wet years. During dry years, the reservoir would augment instream flows by using the power pool, releasing more water to meet the flow target at Albany. Its capacity would be exhausted in the driest years at which point Lookout Point would supply additional water and reach its Alternative 5 minimum in Figure 3.2-167. As compared to Alternative 2B, storage elevations for both Hills Creek and Lookout Point would be slightly lower across all years because of the higher refined integrated temperature and habitat flow regime mainstem targets, it would also be lower than the NAA. Spring mainstem releases in Alternative 5 would be higher than in Alternative 2B, and as a result, the reservoirs would be more likely to run out of storage and pass inflow in the driest years.

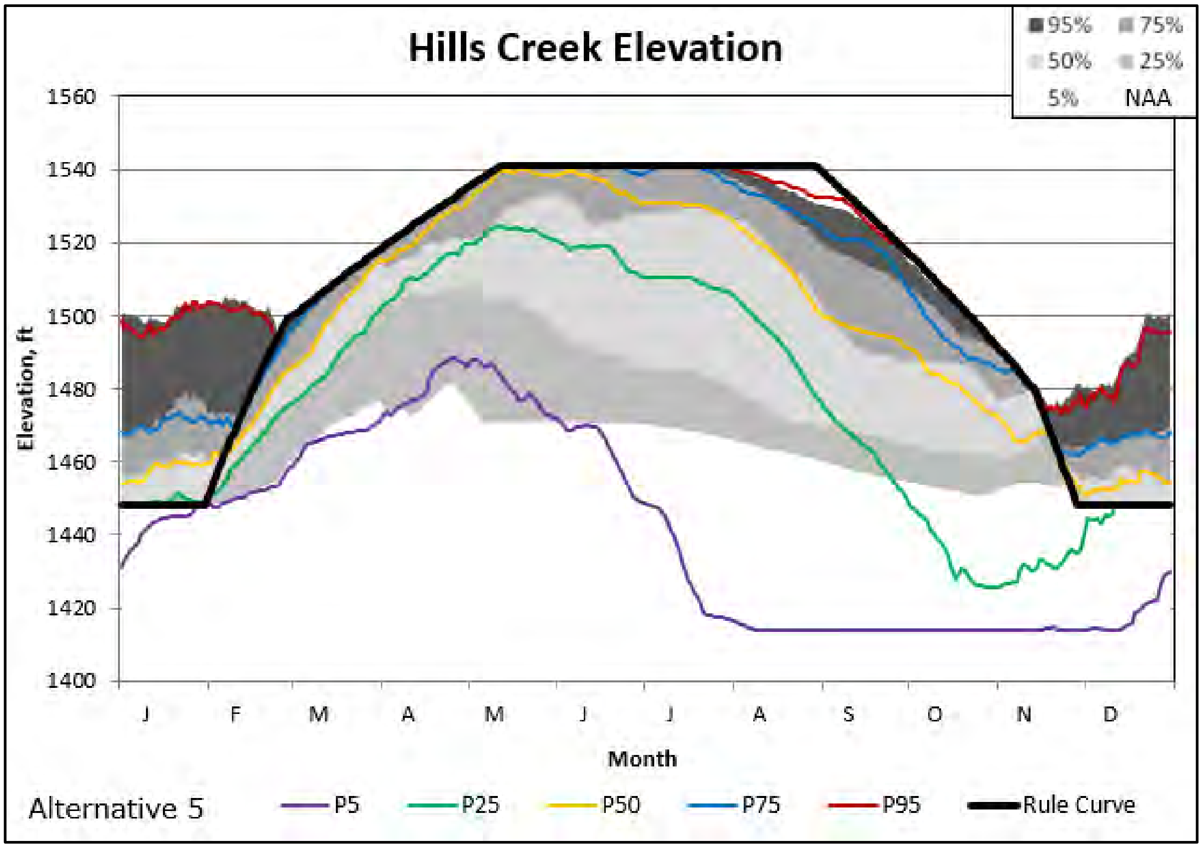



**Figure 3.2-166. Alternative 5 Hills Creek water surface elevation non-exceedance compared with NAA**

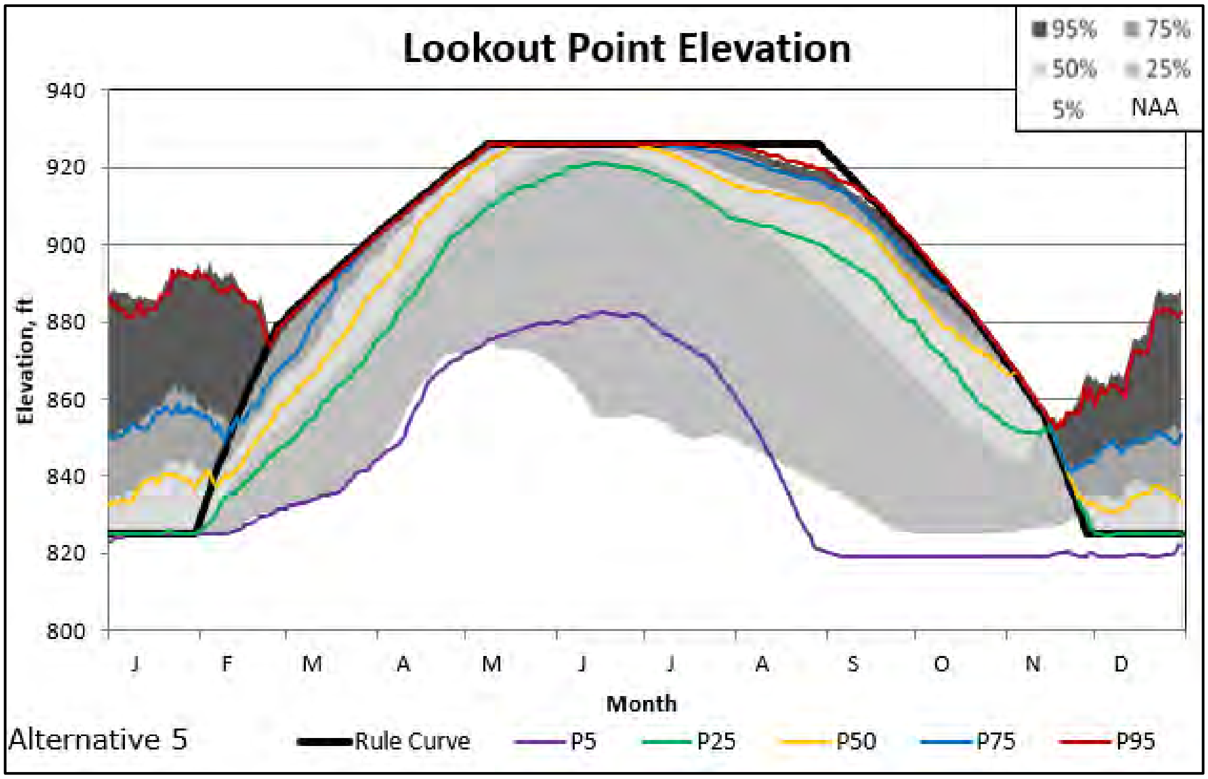



**Figure 3.2-167. Alternative 5 Lookout Point water surface elevation non-exceedance compared with NAA**

Fall Creek reservoir (Figure 3.2-168) would have the same deep fall reservoir drawdown to the bottom of the reservoir in Alternative 5 as the NAA. Therefore, reservoir releases and elevations would vary only slightly from the NAA in Alternative 5.

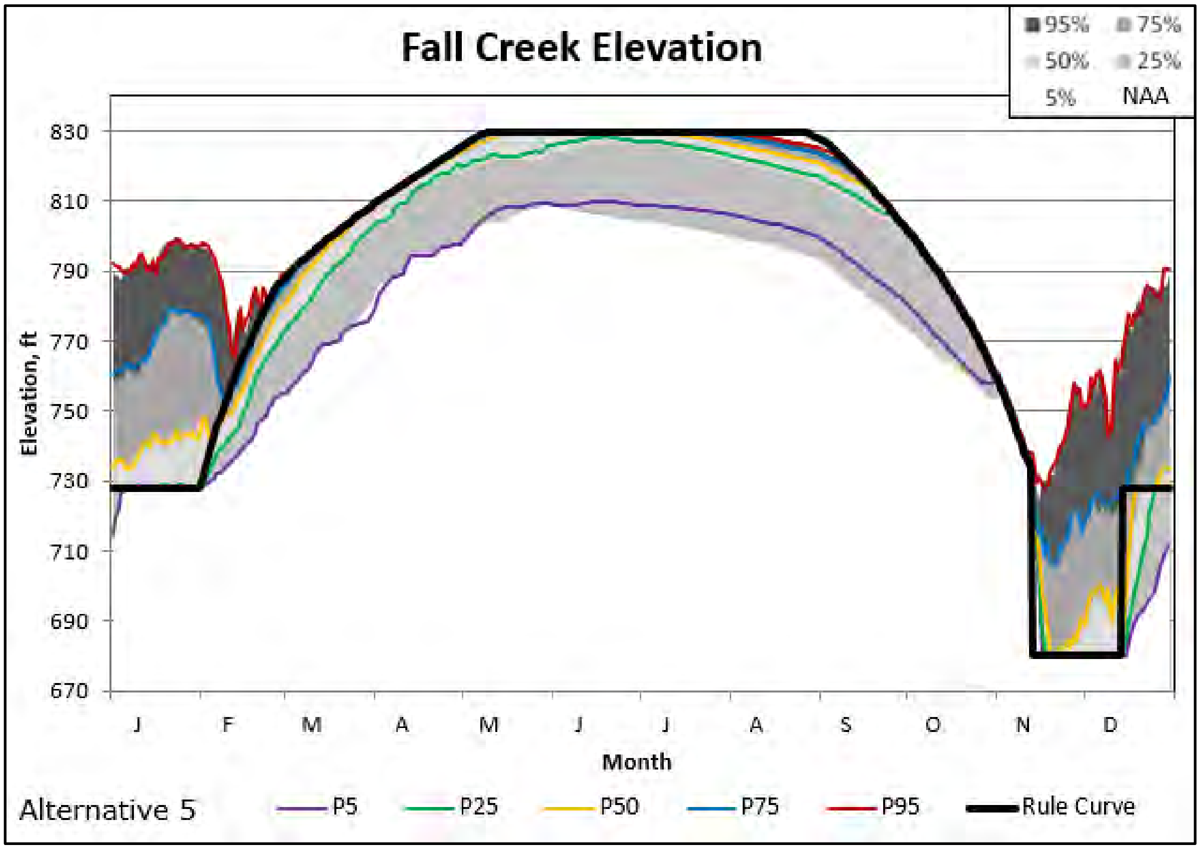



**Figure 3.2-168. Alternative 5 Fall Creek water surface elevation non-exceedance compared with NAA**

At the downstream control point at Jasper (Figure 3.2-169), the shift in flow releases would be evident, especially in dry years, with lower flows in the spring and higher flows in the summer and fall. The increased fall flows during wet years as compared to the NAA would be due to the reservoirs starting at a higher elevation prior to drafting for flood season. There would be more water to release from the reservoirs so there would be higher flow downstream of them.

In the spring of the driest years, refined integrated temperature and habitat flow regime targets at Salem would be lower than the NAA. This would result in lower releases from Hills Creek and Lookout Point and lower flows at Jasper. Fall flows would also be lower in the driest years when Lookout Point and Hills Creek would run out of water, making up for the lack of releases from Cougar. This would happen slightly more often in Alternative 5 than in Alternative 2B because of the higher mainstem flow target at Salem. Since the reservoir would empty earlier, fall flows at Jasper in the driest years would be lower in Alternative 5 than in Alterative 2B.

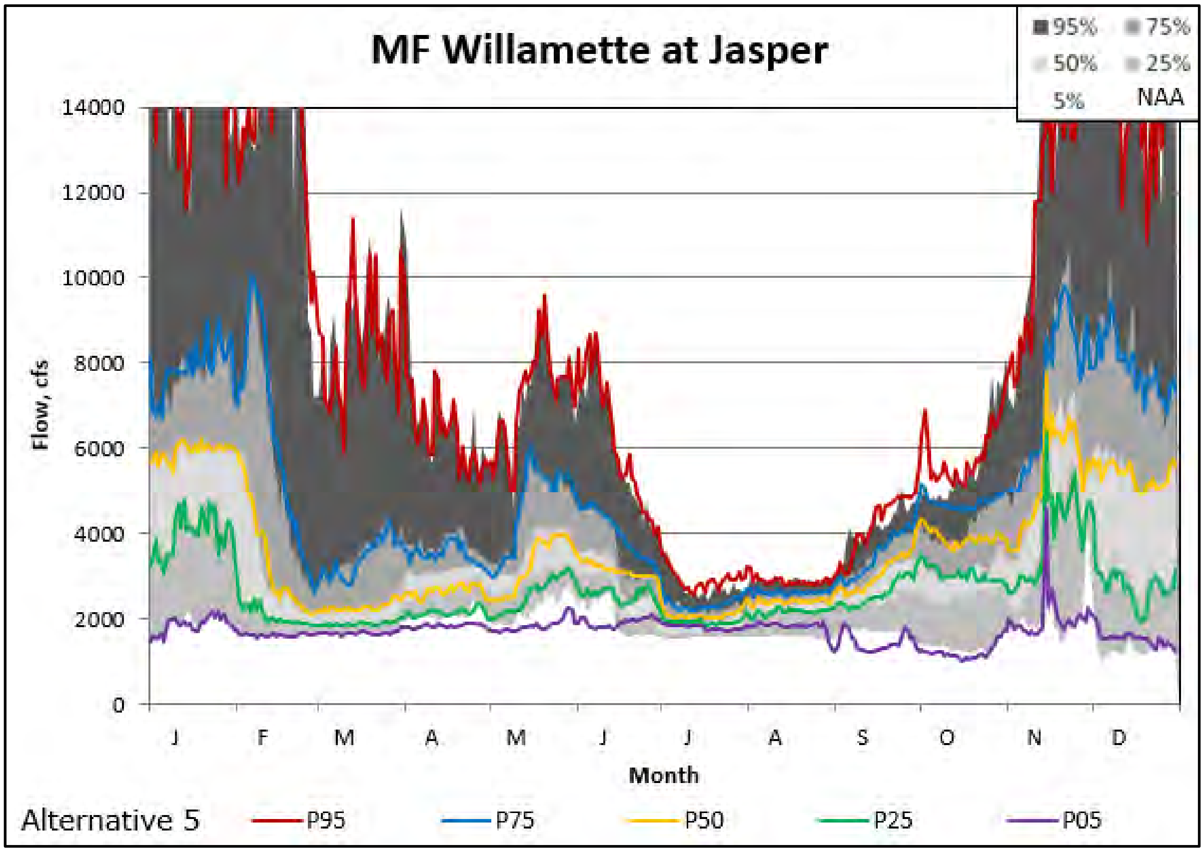



**Figure 3.2-169. Alternative 5 Middle Fork of the Willamette River at Jasper flow non-exceedance compared with NAA**

### *3.2.2.10.5 Coast Fork of the Willamette Subbasin*

For Alternative 5, the Coast Fork subbasin would store more water in the spring and release it during the summer and fall during dry years and it would be generally similar to the NAA in wet years. Reservoir elevations would be somewhat higher at both Dorena (Figure 3.2-170) and Cottage Grove in Alternative 5 during the late spring and summer, with other times similar to the NAA. Dorena and Cottage Grove release slightly more water in the spring than in Alterative 2B to meet the higher mainstem target and draft to lower elevations as a result, but do not run out of water. Figure 3.2-171 shows the control point at Goshen. Since the pools would stay higher throughout the summer, more water is released during September and October.

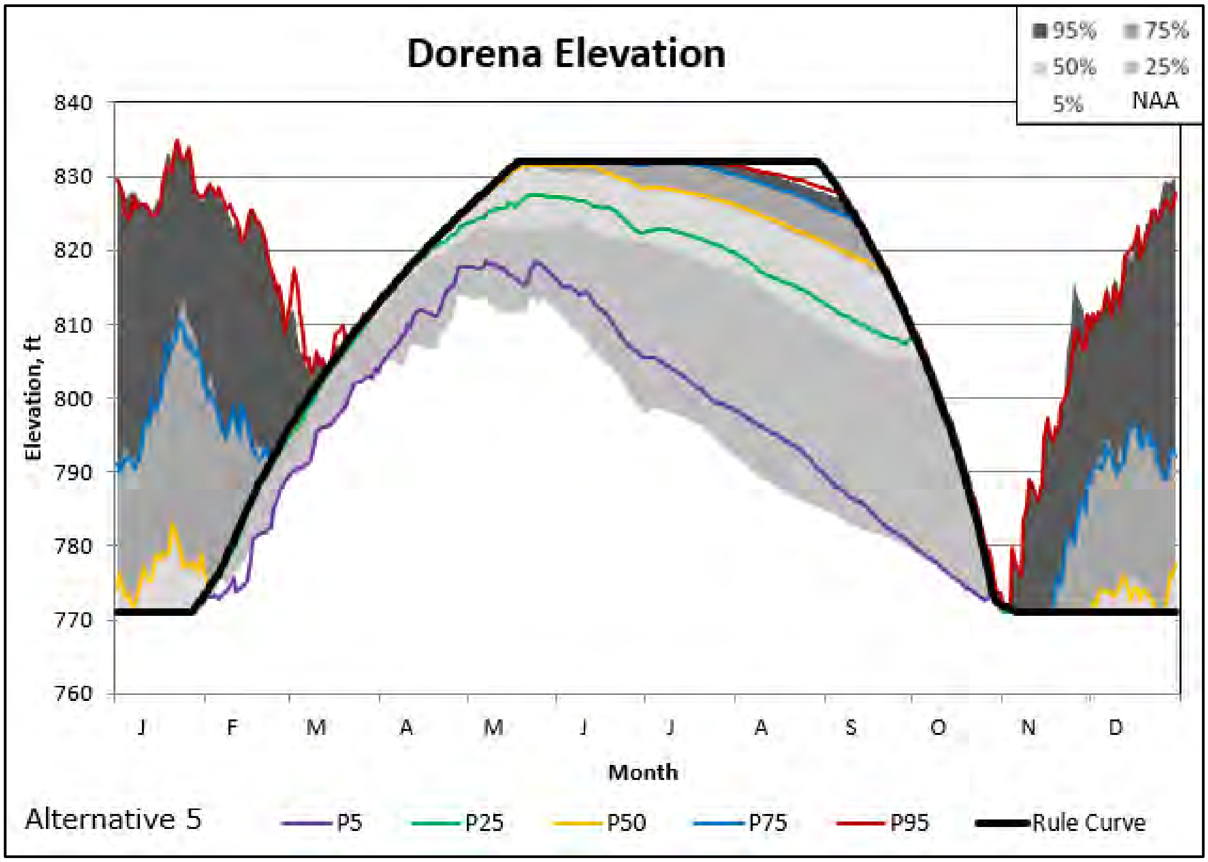



**Figure 3.2-170. Alternative 5 Dorena water surface elevation non-exceedance compared with NAA**

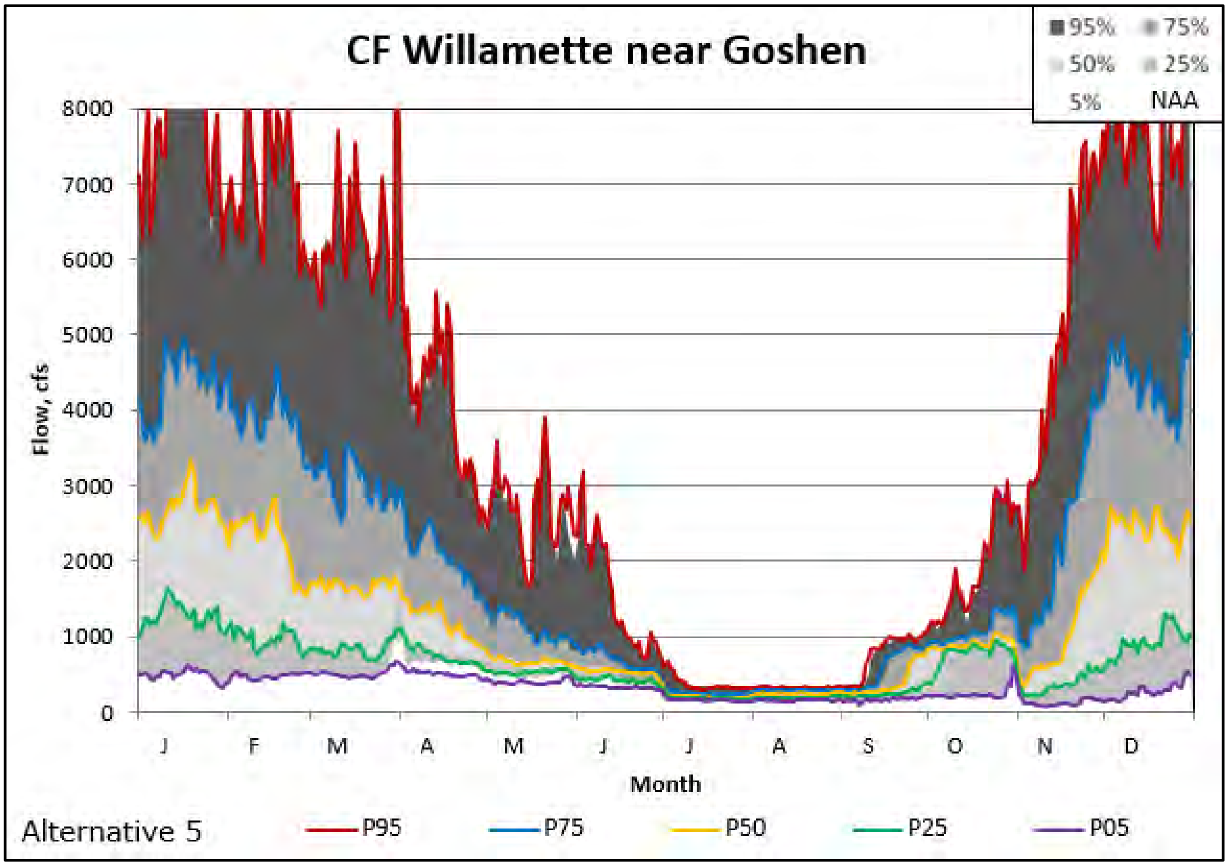



**Figure 3.2-171. Alternative 5 Coast Fork of the Willamette River at Goshen flow non-exceedance compared with NAA**

### *3.2.2.10.6 Mainstem Willamette River*

Alternative 5 would alter the regulated hydrology of the mainstem Willamette River control points under the refined integrated temperature and habitat flow regime, storing more water in the spring and releasing it during the summer. The Willamette River at Albany (Figure 3.2-172) would show dry years below their NAA equivalents from April to June and a compressed flow regime through the summer, with the higher flow years reduced and the low flow years increased. The WVS would typically meet the flow target at Albany, missing during September and October of the driest years. As compared to Alternative 2B, flows at Albany would be slightly higher in the spring and more frequently below the target in the fall of the driest years, a result of higher spring targets at Salem occasionally causing Lookout Point and Hills Creek to run out of water.

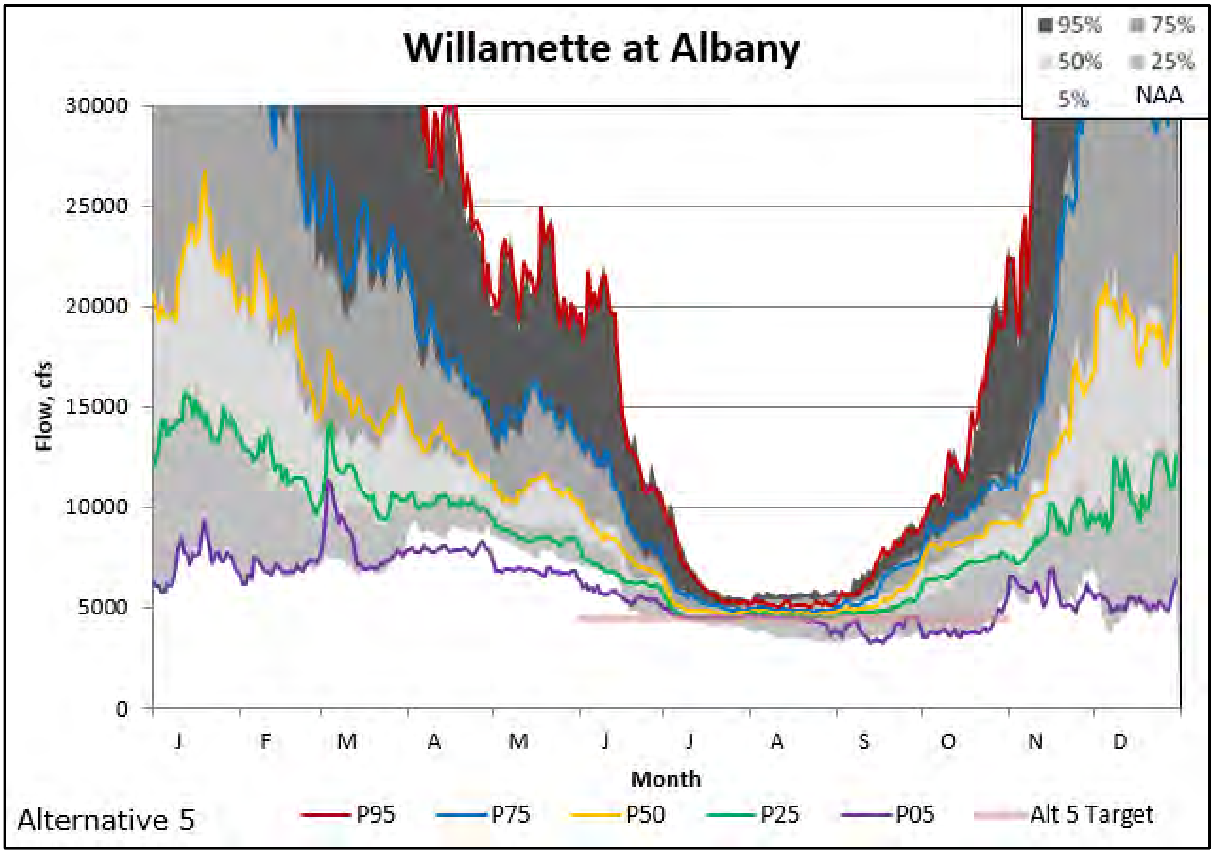



**Figure 3.2-172. Alternative 5 Willamette River at Albany flow non-exceedance compared with NAA**

Like the Albany control point, the Willamette River at Salem (Figure 3.2-173) would show reduced flows from April to June of dry years, while meeting the refined integrated temperature and habitat flow regime target. Summer and fall flows would increase across all years as compared to the NAA. The effect of reduced storage at Cougar would be much less evident at Salem due to the contributions of the Santiam WVS reservoirs. Compared to Alterative 2B, flows in dry springs would be slightly higher reflecting the higher flow targets and fall flows in dry years would be slightly lower after the higher spring targets exhaust storage at key reservoirs.

The increased flows from September to November would be due to the deeper fall reservoir drawdown at Green Peter. These increases would be within the river channel (bankfull is at 90,000 cfs), meaning they would not impact flood risk.

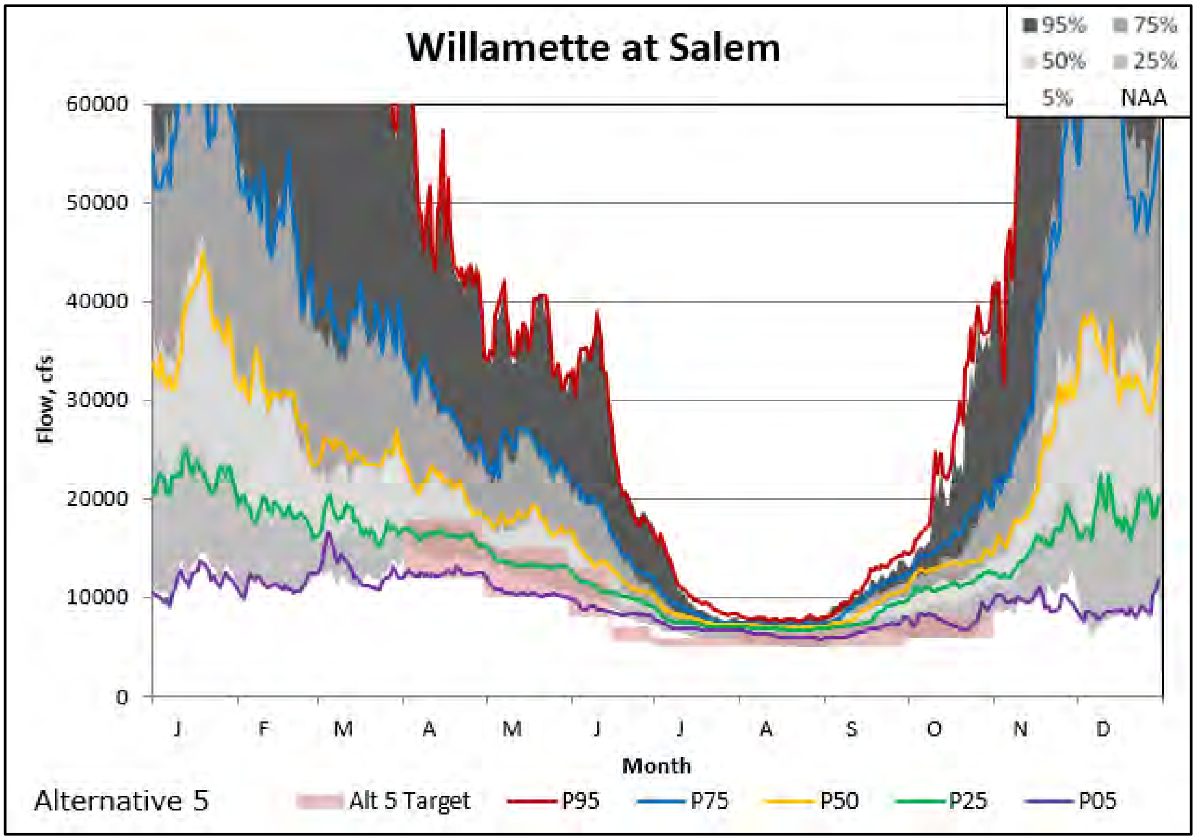



**Figure 3.2-173. Alternative 5 Willamette River at Salem flow non-exceedance compared with NAA**

### *3.2.2.10.7 Near-Term Operations Measure*

See Alternative 2A, Section 3.2.2.4.7, for description of effects due to the Near-Term Operations Measure.

### *3.2.2.10.8 Climate Change*

The WVS will likely experience increasing wintertime flow volumes in the future. Some flood magnification (increased severity during flood season) is also likely. Because the WVS system storage would not increase substantially, it's likely that FRM operations will face future challenges. An upward shift in winter median future project inflows may increase both the average reservoir water surface elevation as well as outflows downstream of the WVS dams. Both Green Peter and Cougar would refill to their conservation pool elevation later in the year after their deeper fall reservoir drawdowns. However, the overall potential benefit may be minimal to future FRM operations. While the lower reservoir elevation at Cougar at the start of flood season is potentially helpful, the storage volume below the minimum conservation elevation is much less than that above it and climate-driven conversion from snowfall to rain may be more impactful than the additional storage. At Green Peter, projections for flow changes are more muted than the higher elevation basins, meaning that it may diminish in importance relative to other WVS reservoirs for FRM operations.

Reservoirs located within higher elevation subbasins, such as Detroit, are likely to see higher rainfall and runoff volumes in the winter. Higher projected temperatures in the future will mean less snowpack than currently experienced. Lower snowpack would also reduce spring volume as the snow melts. Lower elevation subbasin projects such as Fern Ridge and Cottage Grove, with little or no snowpack, are projected to experience higher wintertime flow volumes, but similar peak runoff timing compared to historical baselines.

During conservation season, climate change will affect Alternative 5 similar to Alternative 2B. The refined integrated temperature and habitat flow regime targets allow for lower releases in the spring than the NAA BiOp requirements in the driest years. As a result, some WVS reservoirs can store more water during conservation season as compared to the NAA. However, those reservoirs will have to use more of this stored water to meet downstream flow targets with projected increased variability in the spring shoulder months, drier hotter summers, and lower summer baseflow. Outside of flood season, Cougar Reservoir would likely never fill to minimum conservation elevation due to decreased inflow after its spring reservoir drawdown. Hills Creek and Lookout Point would have to release more water to meet the Albany flow target, substituting for the lack of releases available from Cougar, which would not occur under the NAA.

Across the WVS, reservoirs are projected to have lower water surface elevations as compared to the NAA, though Cougar, Hills Creek, and Lookout Point are most affected. Reservoirs in Alternative 5 would sometimes draft to minimum targeted elevation during the summer, but less often than the NAA, meaning they would be able to augment summer flows for longer than the NAA even with projected decline in late spring and summer flows. The lowest reservoir water surface elevations would occur in the driest years, which would be drier than the WVS currently encounters, as the reservoirs are drafted more to meet downstream flow targets. In addition, increased reservoir evaporation would marginally decrease available water across all reservoirs. Climate change effects, and potential implications as discussed above, draw on the climate change projection and trend information provided in the climate change appendices (F1 and F2).

## 3.3 RIVER MECHANICS AND GEOMORPHOLOGY

### 3.3.1 Affected Environment

#### *3.3.1.1 Introduction*

The River Mechanics and Geomorphology description of the affected environment is divided into two primary portions: 1) the rivers downstream of the WVS and, 2) the dams and reservoirs themselves. In this section, river mechanics refers to the flow levels in the river and closely associated phenomena, such as sediment movement. The floodplain geomorphology refers to the geometry and features of the area that interact with the river. There are many factors that contribute to both, including the basin geology, hydrology, and riparian vegetation. The river and floodplain both shape and interact with each other. For example, the seasonal variability of flow velocity would erode or deposit sediment and change the shape of the channel and floodplain, leading to changed river velocities in a continuous process.

In the downstream portions of the WRB, riverine processes help shape the morphology of the terrain. The WVS substantially affects the hydraulics and morphology of rivers in the WRB. During all seasons, the dams and reservoirs remove sediment and energy from the system and the revetments along the river retard its movement. During the major flood season, peak flows are reduced to decrease damage from flood inundation. All these actions – and others outside of the WVS control – have the effect of reducing the width of the floodplain engaged by the river.

The reservoir elevations vary throughout the year, changing the ponded storage and shoreline with it. In the winter, these changes are for FRM operations. In spring and summer, the reservoirs store water for use during the conservation season and fill up to their full pools as conditions allow. The water surface elevations in the reservoirs and the outflows from dam outlet works have significant effects on the immediate surroundings.

#### *3.3.1.2 System*

There are approximately 465 River Miles (RMs) along the Willamette River and its regulated subbasins below the WVS. Two subbasins, the Clackamas and Molalla rivers, contain revetments but are not downstream of any WVS reservoirs, so they are 'unregulated' by USACE flood damage reduction storage projects

The WVS is multipurpose and the operational goals change throughout the year based on the season. During the major flood season, the goal is to decrease flood damages by reducing the peak flow downstream of the WVS. These operations are readily apparent in the historic record. The WVS was constructed starting in 1942 with Fern Ridge on the Long Tom River and was fully operational for water year (WY) 1969. The peak flows at Albany were reduced substantially after this date. Figure 3.3-1 shows the annual peak from each WY at a long-term flow gaging site on the Willamette River downstream of the WVS reservoirs. Annual peak flows are reduced, but the WVS also reduces potentially damaging flows that are lower than the peak flows shown in Figure 3.3-1.

The high flows, both annual peaks and lesser large flows, from before the construction of the WVS, formed the geomorphic floodplain in the WRB. The amount of energy and peak flows available to the rivers downstream of the WVS is reduced and the area of influence around the main channel has narrowed as an effect of flood damage reduction operations. In other words, the many floodplain terraces, swales, and other geomorphic formations along the Willamette Basin rivers are no longer regularly connected to the channel as they were before the construction of the WVS.

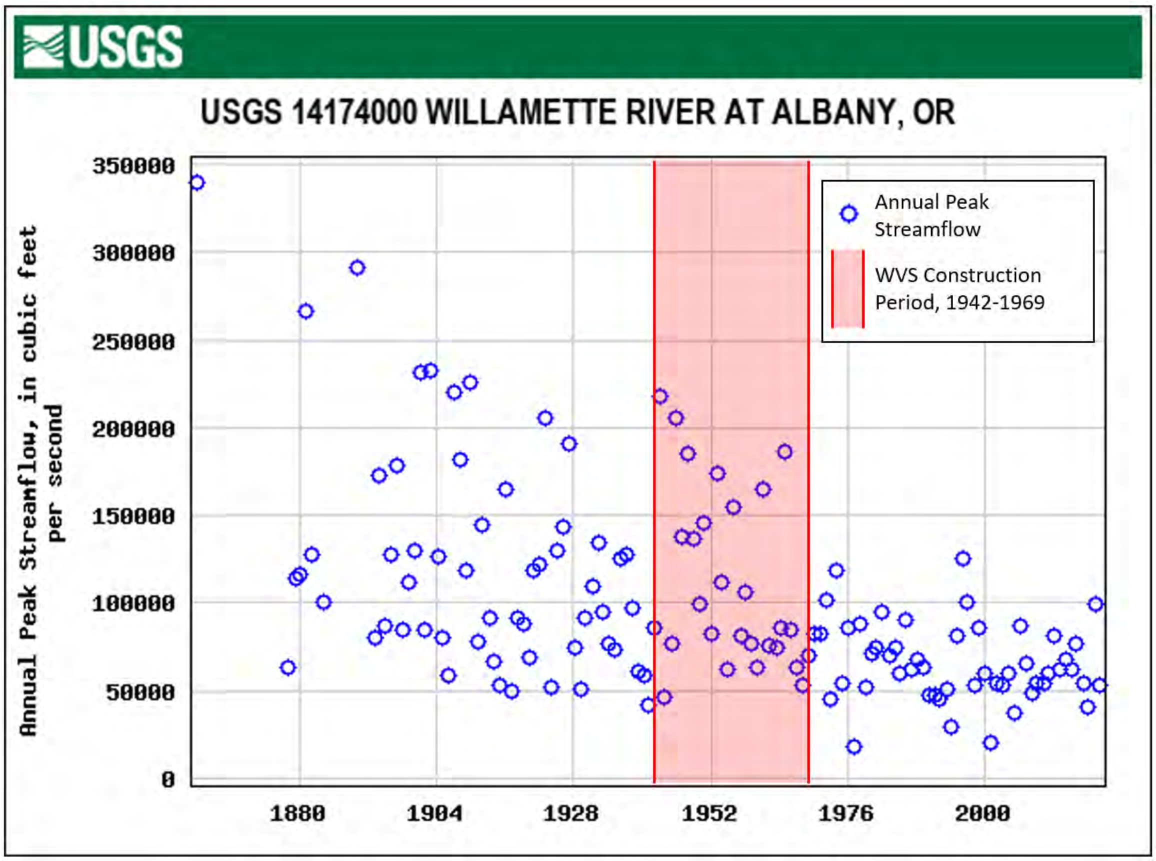



**Figure 3.3-1. Annual observed maximum flow at Albany, OR.**

The rivers are generally steeper further upstream toward the headwaters of the WRB. While the Willamette River above Willamette Falls is nearly flat during low water periods, the upper portions of the North Santiam River and McKenzie River have quite steep average channel slopes of up to 10 feet per mile. Figure 3.3-2 shows the Willamette Valley basin layout. A general geomorphic and hydraulic description of the downstream reaches (Wallick et al. 2013), is included later in this section moving from downstream to upstream.

All regulated tributaries in the WRB except Blue River, South Fork McKenzie, Fall Creek, and Row River contain constructed bank protection revetments, embankments or levees. These structures are part of the WVS and generally constrain the movements of river channels.

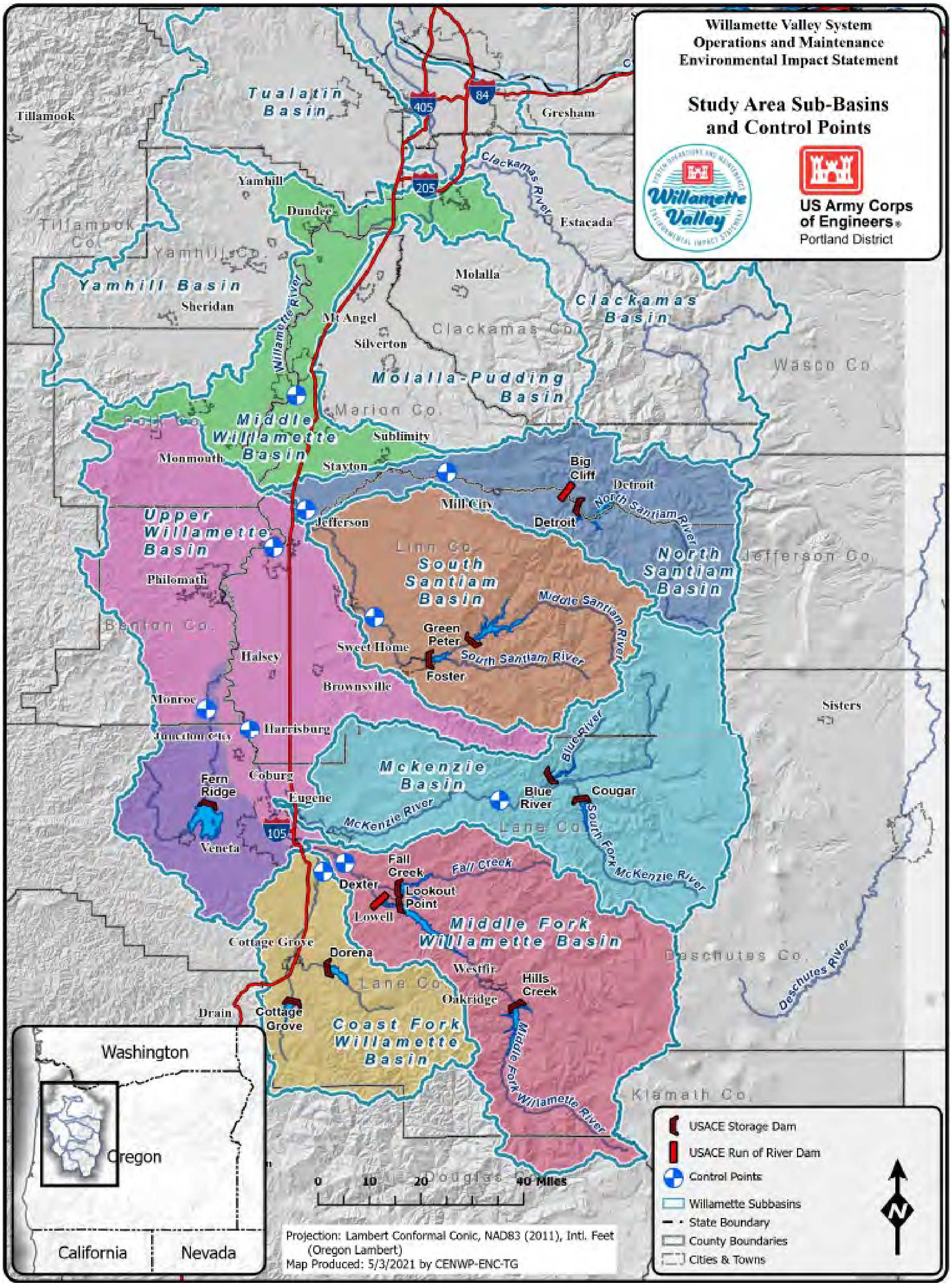



**Figure 3.3-2. Willamette Basin subbasins and WVS layout**

### *3.3.1.3 Willamette Basin Sediment Movement*

Sediment movement in the system is significantly altered by the WVS, both in the reservoirs themselves and in the downstream rivers due to the construction of revetments and hydrologic modifications for flood damage reduction.

#### *3.3.1.3.1 Reservoir Sediment Mechanics*

Coarse sediments (sand and gravel) entering a reservoir typically settle out and deposit as a delta in the upstream end of reservoirs and along the upstream river channels as the flow of the river encounters the reservoir pool. Sediment in the delta (commonly referred to as head of reservoir deposits) can be remobilized farther downstream when the reservoir operating pool lowers (e.g., for seasonal management changes). In dams that operate over a wide range of elevations throughout the year, the upstream extent of reservoir backwater and the location where coarse sediments deposit may shift considerable distances. Reservoirs with larger changes in water surface elevation and shallower slopes near the head of reservoir would have larger coarse sediment deltas. Coarse sediments rarely pass a dam with a significant pool impounded.

Fine suspended silts and clays tend to transport past the delta and slowly settle out of the water column along the reservoir bottom as a lakebed deposit. Finer sediment would typically travel further in the reservoir: the smallest sediment particles may never reach the bottom of the reservoir and would pass through the dam with the outflow. Reservoirs with large storage volumes relative to the annual volume of water passing through tend to trap more suspended sediment than reservoirs with smaller relative storage volumes. The geometry of the reservoir can also affect fine sediment trapping: sediment would take longer to travel to the bottom of a reservoir that is relatively long and deep as compared to a similar volume reservoir that is wide and shallow. Figure 3.3-3 shows a conceptual diagram of sediment trapping in a reservoir.

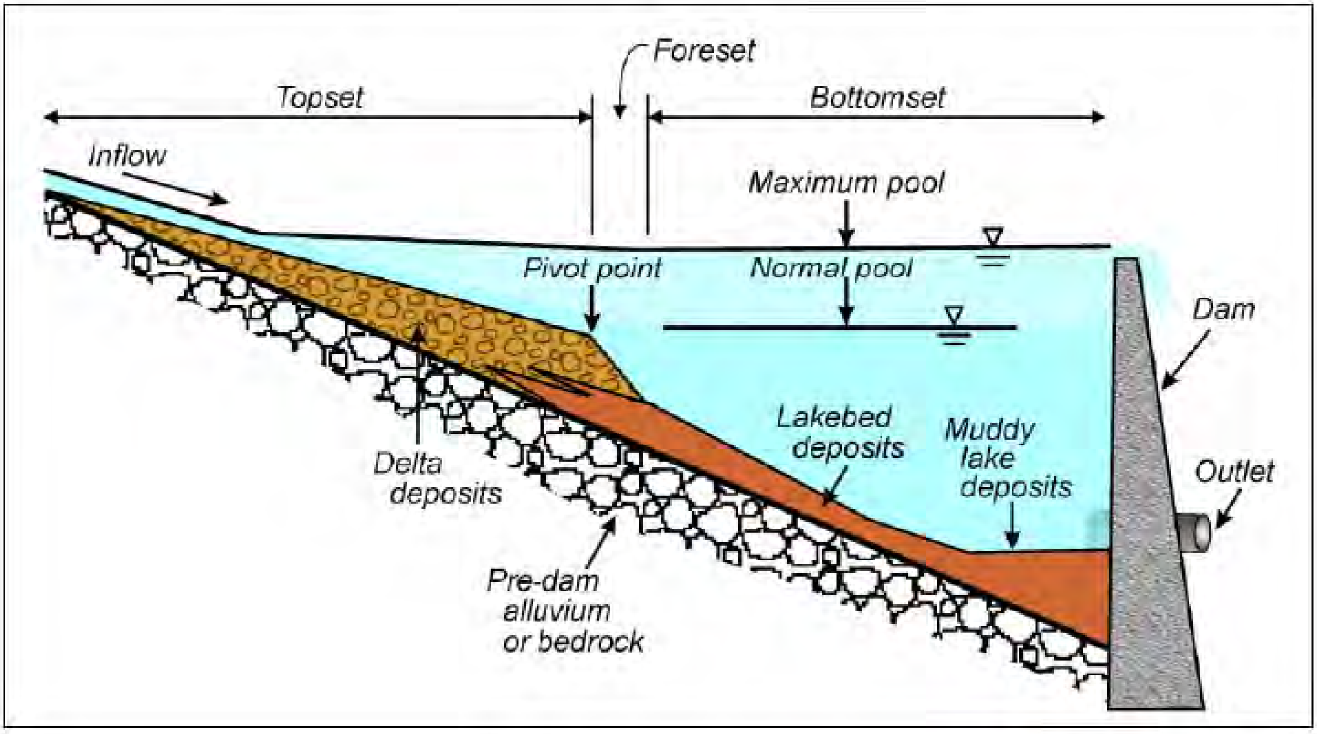



**Figure 3.3-3. Idealized sediment profile within a dam-controlled reservoir**

The estimated median sediment trapping efficiencies for the WVS (excluding the reregulating projects Big Cliff and Dexter) are shown below. These calculations use the WVS PEIS hydrology inflow dataset for storage and inflow volume (see appendix C). This target elevation generates useful comparison of median trapping efficiency across the WVS as most sediment generated from upstream sources transports into the reservoirs during the flood season flows. More broadly, since the trapping efficiency is based on a log-scale comparison of water volumes, the estimated trapping efficiency would not change significantly if the actual amount of impounded water is somewhat different than the rule curve target.

Estimated Trapping Efficiency of WVS:

- Blue River – 81%
- Cottage Grove – 81%
- Cougar – 91%
- Detroit – 91%
- Dorena – 81%
- Fall Creek – 82%
- Fern Ridge – 80%
- Foster – 67%

- Green Peter – 93%
- Hills Creek – 94%
- Lookout Point – 88%

It is important to note that these values are estimates based on comparing water volumes and not measured sedimentation. Also, as noted above, every reservoir in the WVS traps nearly all coarse sediments (gravels and sands) in the pool (O'Connor et al. 2014). These are included in the values above, and generally the only sediment passing a reservoir would be fines (silt and clay sized sediments).

There are two existing reservoir sediment mobilization models in the WVS, at Detroit (USACE 2016a) and Lookout Point/Dexter (USACE 2015c). The intent of both studies was to assess the movement of accumulated sediments in and out of the reservoir during a deep drawdown reduction in the pool elevation to the lowest outlet in each dam. In addition, USACE has lowered the reservoir elevation at Fall Creek during the fall in recent years with a deep drawdown.

Figure 3.3-4 shows the results of the scour analysis during a modeled drawdown of Lookout Point. The Lookout Point model was designed to investigate sediment movement in and out of the reservoir in preparation to replace the spillway gates which required a lowering of the reservoir.

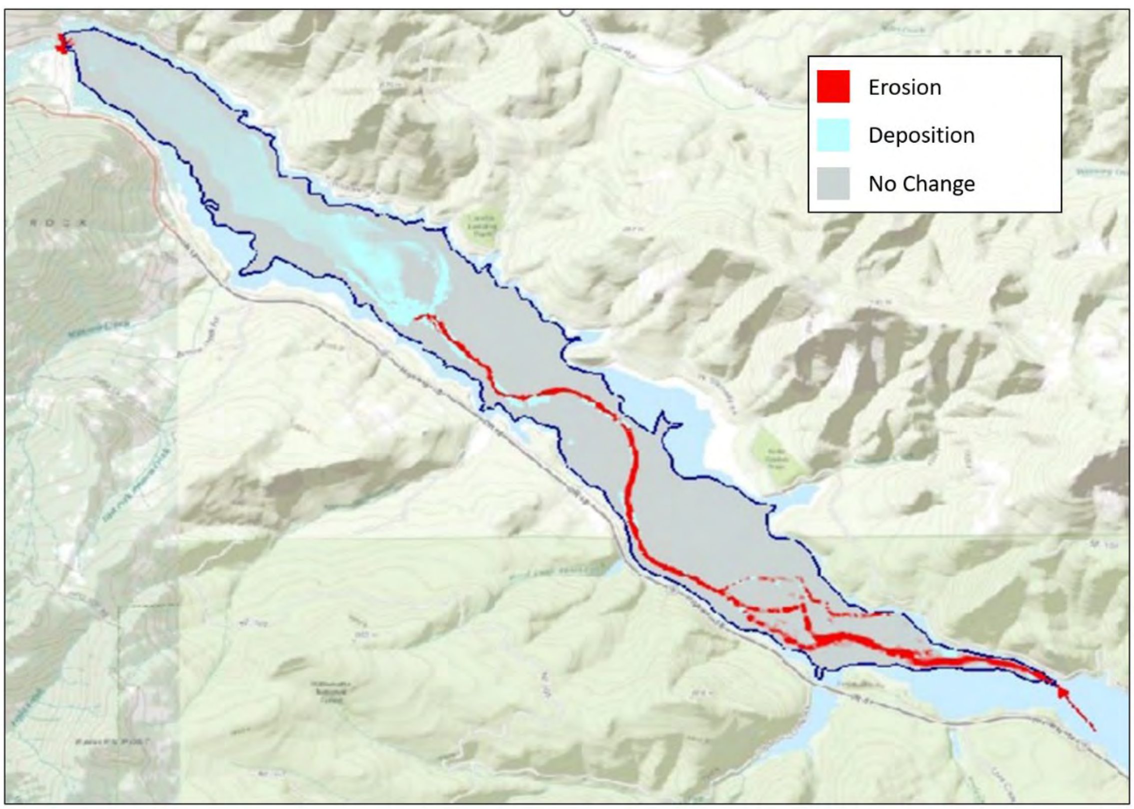



**Figure 3.3-4. Modeled sediment mobility during modeled Lookout Point drawdown**

The results show that the sediment accumulated at the upstream end of Lookout Point since construction (bottom right in the figure) moving closer to the Dam (top left) and a limited amount of sediment passing through to Dexter Reservoir downstream.

*3.3.1.3.2 River Sediment Mechanics*

Most coarse sediments in the WRB are from the Cascade Mountains, which primarily supplies volcanic basalts. This material degrades relatively slowly and typically disappears from river channels due to coarse sediments being broken into smaller particles as they are carried downstream (O'Connor et al. 2014). The McKenzie and North Santiam Rivers currently contribute the highest amount of sediment to the mainstem Willamette (Wallick et al. 2013). These two rivers have larger portions of their drainage basins that are both relatively steep and outside the control of any WVS dam and reservoir. Although the Coast Range does contribute substantial sediments, the soft sedimentary sandstone of the lower mountains rapidly degrades to silt and clay (O'Connor et al. 2014) and is transported as suspended and wash load. (The "wash load" is the portion of sediments that remains suspended even without water flow, thereby contributing to turbidity.) Figure 3.3-5 shows gravel bar formation in the North Santiam River south of Stayton, Oregon. The side channels and various ages of vegetation and gravel bars are evidence that the river channel is mobile within its immediate floodplain in this area.


**Figure 3.3-5. Gravel bars and side channel morphology in North Santiam River south of Stayton, OR.**

Most sediment transport capacity in riverine environments occurs during near channel bankfull water conditions. Bankfull refers to the water level stage that just begins to spill water out of the channel into the floodplain. As noted in Section 3.2, Hydrologic Processes, the frequency of these events has been reduced by the upstream storage operations of the WVS. Combined with the sediment capture in the reservoir pools, the basin modifications have had the effect of reducing sediment load in the Willamette Valley. In total, the WVS is estimated to reduce the estimated coarse sediment flux in the WRB by about two-thirds, from about 199,000 to 72,000 cubic meters per year (Wallick et al. 2013).

As with hydrology and peak flows, the sediment movement in the rivers closest to the dams and reservoirs is most heavily affected by their construction. Generally, the streambed in these areas coarsens (or 'armors') over time as the water from the dam outlets erode the fine material in the downstream channel. In a natural system, this material would be replaced by incoming transporting sediments, but these sediments are instead trapped in the reservoir itself. This coarsening effect is not limited to river reaches directly downstream of reservoirs and, over time, the regulated rivers in the WRB have coarsened (Klingeman 1987; Minear 1994). Simultaneously, the regulation of the peak flow in the main reaches reduces the transport capacity for coarse sediment load. The sediment coming into the main reaches from downstream rivers still contains the coarse sediment, in contrast to the water from the reservoirs. The reduced peak flows leave the incoming coarse sediment behind as finer material moves downstream. The combined effect of these two riverine processes is an overall coarsening of riverbeds in the regulated portions of the WRB.

Coarse sediment availability and mobilization and large changes in flow all contribute to river channel migration. The segments of the mainstem Willamette River that currently experience the most migration due to these factors are the areas downstream of the confluences with the McKenzie River and Santiam River. As the river flows away from these confluences, the river adjusts to its larger flow, the coarse sediment is lost to attrition and the river is more incised in the sections between Corvallis until the confluence with the Santiam – farthest away from the McKenzie River – and downstream of Salem – furthest away from the Santiam River (Wallick et al. 2013).

##### *3.3.1.3.3 Bank Stabilization by Revetments*

USACE, private landowners, and others have built revetments along the historically mobile river reaches of the WRB. Figure 3.3-6 shows a picture and cross section of a revetment north of Salem, OR – individual revetments vary in geometry based on the local river and bank conditions. These structures typically consist of large stones (riprap) placed along the river to prevent the bank from eroding further and protect adjacent property. The stone revetments often have accessory structures like drift barriers, which are placed at the mouth of high-water overflow channels to collect debris and reduce the velocity of flows into the channel; and groins, which extend into the channel diagonally or perpendicularly to the riverbank in order to reduce near-bank velocities. Revetments are typically placed on the outside of a river bend where erosion is most likely to occur but are sometimes also used to realign or straighten the main channel.

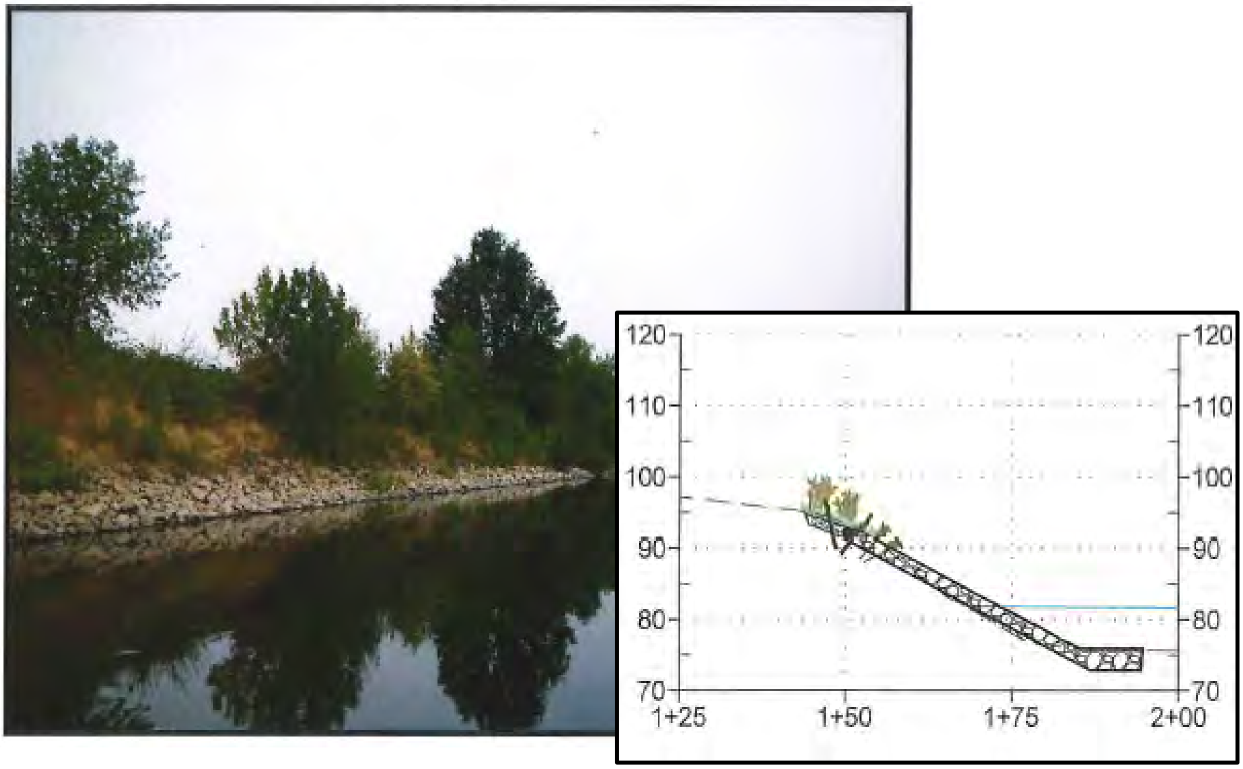



**Figure 3.3-6. Example Willamette River revetment north of Salem, OR, with typical cross section**

USACE has frequently constructed two other types of hydraulic structures: levees and embankments. Levees are designed to protect an area from high flood waters and typically connect to high ground on either side. There would necessarily be a water surface elevation differential inside and outside of the levee. USACE has also constructed hydraulic embankments in some locations. These linear structure appear like levees but can be perforated with culverts or may not connect to high ground. Often, these structures increase channel flow capacity (as along the Long Tom River downstream of Fern Ridge Dam) but can be designed for other purposes. Importantly, neither embanclipkments or revetments are designed to protect an area against flooding. In summary, levees mitigate flooding, revetments mitigate erosion, and embankments can increase channel capacity, redirect flow or serve other functions as necessary. There are projects that incorporate aspects of each into their design.

Revetments are most common in river reaches with the most historic channel migration, such as the McKenzie, upper mainstem Willamette, and South Santiam rivers. Currently, about 26% of the banks of the mainstem Willamette between Eugene and Portland have revetments. A significant portion of the rest is geologically stable (e.g., bedrock canyon, banks made of compacted gravels resistant to erosion, etc.), so approximately 25% of the river is able migrate freely through erodible soils, down from 80% in 1932 (Wallick et al. 2007).

Along with the lower water levels due to flood damage reduction operations, revetment projects can have the effect of partially restricting previously active floodplain interaction with the main channel. Riprap is typically placed on a slope with no associated embankment. Some revetments have placed earthen embankments or plugs where the existing bank is uneven in elevation or planform. Typically, any embankment that is part of a revetment project only provides a consistent surface for facing with riprap and does not stop water from moving behind them like a levee. Riprap on the landward side of an embankment slope prevents erosion when floodwaters flow over the embankment into the floodplain. Where revetment projects with embankments isolate previously connected low areas, suspended sediments passing into the floodplain over the revetments would then fall out of suspension in the lower energy areas behind the structure and, over the course of years, fill in previously active areas with fine sediment.

Since the revetments constrain lateral movement of the river, the material in the banks is no longer available to be eroded and transported downstream as bed and suspended sediment load. The accumulated material is lost to the floodplain from the river as the revetments reduce bank erosion in the system.

#### *3.3.1.4 Lower Willamette River*

The Lower Willamette River – below Willamette Falls at RM 26 – is not included in the WVS PEIS. It is tidally influenced by the Columbia River and the hydrology of that reach is better suited in a discussion of the Lower Columbia River estuary. Please refer to the Columbia River System Operations EIS for information on this reach (USACE et al. 2020).

#### *3.3.1.5 Middle Willamette River*

The Middle Willamette River, from Willamette Falls to the Santiam confluence, is divided into two parts. The Willamette Falls backwater, commonly referred to as the Newberg Pool, extends up to about RM 50. The channel slope is about 1.2 ft/mile and the water surface can be nearly flat during the summer, though higher flows steepen the water surface profile somewhat. The river is confined by canyons and high terraces in some areas and the geomorphic floodplain is narrow: generally, between 1,000 to 3,500 feet across. The natural backwater associated with the Willamette Falls means there is less energy available for channel movement. The Willamette River has few side channels and limited floodplain interaction downstream of RM 50.

Upstream of Newberg Pool, the river increases in slope somewhat (1.8 ft/mile) but remains a very low gradient river. There are gravel bars with the material supplied by the Santiam River and occasional side channels, but the river is predominately a single-threaded channel. The river still has relatively steep banks, between 10 and 20 feet high. High flows are required for floodplain interaction. The river is geologically constrained in certain places – such as south of Salem, Oregon – but the geomorphic floodplain is generally wider in this stretch at 1 to 4 miles across. The furthest downstream WVS revetments are in this reach.

### *3.3.1.6 Upper Willamette River*

Upstream of the supply from the Santiam River, gravel bars are much less prevalent. The largely single-thread channel, up until the Corvallis area, remains low gradient, (1.5 ft/mile) and the geomorphic floodplain is between 3000 feet and 3.5 miles. The river channel is relatively stable due to geographic constraints. Fewer revetments were constructed in this reach than upstream, primarily due to the natural stability of the reach.

Upstream of Corvallis is the most active and varied portion of the mainstem Willamette River. Previous work (Wallick et al. 2007) has described this area as a "wandering gravel-bed river". The overall channel slope steepens considerably to 4-5 ft/mile and the channel is unconstrained by geography like it is downstream. This is the widest geomorphic floodplain in the mainstem Willamette (upper, middle and lower), at up to 5 miles. Gravel bars are frequent and larger flows can sometimes realign the channel in a relatively short period of time. However, these events, called river avulsions, have decreased by about 70% in the 20th Century (Wallick et al. 2007). Figure 3.3-7 shows one such location south of Peoria, Oregon, comparing August 2005 and August 2006, where a flood in January 2006 cut off an existing meander, straightening the channel. The historic response to the Willamette River's ability to wander was to construct revetments, so this area of the mainstem has the greatest number and longest total length of them.


**Figure 3.3-7. Willamette River realignment before and after January 2006 flood, south of Peoria, OR**

### *3.3.1.7 North Santiam River*

The North Santiam River is the steepest reach downstream of any WVS, with an average slope of 14 ft/mile, with the highest slopes as it approaches Big Cliff Reregulating Dam. There are many secondary channels and gravel bars. Channel movement and avulsions (where a river channel shifts location) are relatively common in the North Santiam as compared to other rivers in the WRB. The North Santiam is the source for much of the sediment in the mainstem Willamette River downstream of the confluence. The geomorphic floodplain is a still relatively narrow with widths between 3500 feet to 1.5 miles due to bedrock and other hardened geologic features.

#### *3.3.1.8 South Santiam and Mainstem Santiam Rivers*

The South and mainstem Santiam rivers have wide geomorphic floodplains, up to 3 miles across. This is due to a combination of moderate overall channel grades – ranging from 4-6 ft/mile – and unconstrained geology. Historically, this would have resulted in an active channel, but most of the river is single thread currently due to the construction of revetments. Vegetation has colonized previously active gravel bars, further hardening the modified morphology. Since the area surrounding the river channel is relatively flat across the floodplain, the inundated area can expand quite quickly once floodwaters overtop the riverbanks.

#### *3.3.1.9 Long Tom River*

The Long Tom River is lined with embankments along nearly its entire length downstream of Fern Ridge Reservoir to its confluence with the Willamette River. These embankments were designed so that the highly modified channel can pass the output from Fern Ridge Dam. There is limited interaction between the channel and its historic floodplain because of the embankments, but culverts in the embankments allow for regular inundation of floodplain regions.

The river was shortened from 36.5 miles to 23.6 miles. A series of seven drop structures were also built with the intent to reduce channel velocity and decrease erosion, while still moving water downstream efficiently.

#### *3.3.1.10 McKenzie and Blue Rivers*

Near the confluence with the mainstem Willamette River (north of Eugene and south of Coburg), the McKenzie River floodplain is up to 2 miles wide, but the channel is single thread due to modifications such as revetments and gravel mining along the banks. The floodplain is lower with respect to the channel than most other rivers in the WRB and inundation is possible at levels as low as the 50% Annual Exceedance Probability flow (commonly referred to as the 2-year flood).

The McKenzie River steepens upstream of Hayden Bridge (about RM 10, upstream of the confluence with the Mohawk River) to 10 ft/mile, with the geomorphic floodplain narrowing, intermittent multithread sections, and increasing prevalence of gravel bars. Further upstream, near Blue River and Cougar dams (Figure 3.3-8), the river is increasingly single thread in a canyon and the banks are generally forested.

There is about 1.6 miles of river between Blue River Dam and the confluence with the McKenzie River. The channel is modified to accommodate the outlet works of the dam, but there are no revetments on Blue River.

**Figure 3.3-8. Winter Drawdown on Cougar Reservoir**

### *3.3.1.11 Middle Fork of the Willamette River and Fall Creek*

The Middle Fork between the mainstem Willamette and Dexter Reservoir has little inflow that is not controlled by the upstream WVS (Hills Creek, Lookout Point, Dexter and Fall Creek). The geomorphic floodplain is constrained by the foothills of the Cascade mountains and is between 3500 feet and 1.5 miles wide. The proximity of the WVS reducing peak flow and sediment supply, and construction of revetments in the most mobile areas, means that the Middle Fork is largely stable through this reach. Historic gravel bars have forested, further hardening the banks against movement.

There are about 7 RM of Fall Creek below the Fall Creek Dam. The geomorphic floodplain is confined by hills on each side and ranges from 1000 to 4000 feet across. Upstream of Little Fall Creek (RM 3), the effects of the reservoir predominate. The channel is oversized for its current reduced peak flows and lack of sediments. From Little Fall Creek to the confluence with the Middle Fork, there are a few side channels and more sediment as the two floodplains interact and merge.

#### *3.3.1.12 Coast Fork of the Willamette and Row Rivers*

Near the confluence with the Middle Fork to form the mainstem Willamette, the Coast Fork has several secondary channels and swales. This area also has significant developed areas and historic gravel mines. Upstream of the Highway 58 bridge (RM 6), the geomorphic floodplain progressively narrows and is more confined by the hills up to the WVS (Cottage Grove and Dorena). The channel is single thread for most of its length, modified with both revetments and channel capacity straightening through urbanized areas. Trees have stabilized most historic gravel bars.

### 3.3.2 Environmental Consequences

#### *3.3.2.1 Methodology*

Environmental consequences are identified for each of five river mechanics metrics based on thresholds of relative change (Action Alternative versus NAA) normalized to four levels (None/Negligible, Minor, Moderate, and Major). To facilitate interpretation, the results for the estimated environmental consequences are presented in the following sections organized by each alternative and grouped by sub-basin and then hydraulic operation (storage projects or run-of-river reservoirs and free flowing reaches).

Both quantitative and qualitative assessment methods were used to assess relative potential changes to river hydraulics, sediment supply and geomorphology for each PEIS alternative. Five quantitatively informed, but fundamentally qualitative metrics were developed to represent various physical characteristics and processes that could affect storage reservoirs, run-of-river reservoirs, and free-flowing reaches.

Environmental consequences related to river mechanics processes were evaluated in a comparative nature between and the action alternatives and the NAA. The general approach for evaluating system response for river processes was to use the historical period of record (POR) daily output from the quantitative Hydrologic Engineering Center Reservoir Simulation System (HEC-ResSim) as analysis inputs to compute or inform a suite of five metrics as described in this section and in further detail in Appendix C. Details of the HEC-ResSim model and analysis are located in section 3.2.

Note that in order to accurately represent spatiotemporal effects, the HEC-ResSim model analyses were applied using daily average values over the entire WVS basin and metrics presented herein are limited to the previously identified WVS projects. Due to a number of limitations associated with the H&H modeling process (see Appendix B), the baseline conditions established by the NAA results may not necessarily completely characterize the actualized conditions. Nonetheless, considering the size of the study area, the NAA and action alternative results were deemed sufficiently representative to adequately describe the hydrology and hydraulics as required to establish a general baseline of the study area for trend and departure analysis.

For a detailed description of the integrated operations and their effects to flows and reservoir stages throughout the WVS, see chapter 3.2, Hydrologic Processes.

##### *3.3.2.1.1 Alternative Comparison Thresholds*

The analysis method for river mechanics and geomorphology is qualitative, driven by quantitative storage and flow metrics. Visible or measurable expected change to a field observer drives the analysis. The basis for the quantitative metrics and the resulting qualitative descriptions is the hydrology and HEC-ResSim outputs for each alternative, as compared to the NAA. There are four levels of magnitude of effects, three levels of duration and three levels of extents when comparing the NAA to the others as shown in Table 3.3-1 below.

**Table 3.3-1. Evaluation Criteria for Potential Effects to River Mechanics and Geomorphology**

| Effect Magnitude | Criteria |
|---|---|
| None/Negligible | The resource area would not be affected, or changes or benefits would be either nondetectable or, if detected, would have effects that would be slight and localized. The area extent of effects would be small (limited) and would not require additional consideration or mitigation. |
| Minor | Changes to the resource would be measurable, although the changes would be small and localized. The duration of effects may vary. |
| Moderate | Changes to the resource would be measurable and have either localized or regional-scale adverse effects/benefits. |
| Major | Changes would be readily measurable and would have substantial consequences on a local or regional level. |
| **Effect Duration** | **Criteria** |
| Short-term | Changes to river mechanics and/or geomorphology would last less than two years. |
| Medium-term | Changes to river mechanics and/or geomorphology would last between two and five years. |
| Long-term | Changes to river mechanics and/or geomorphology would last throughout the duration of the project (2050). |
| **Effect Extents** | **Criteria** |
| Local | Changes to river mechanics and/or geomorphology would be confined to the dam/reservoir or river. |
| Regional | Changes to river mechanics and/or geomorphology would be perceived throughout a single county, multiple counties, or the entire WVS. |
| State-wide | Changes to river mechanics and/or geomorphology would be perceived throughout the entire state. |

As an example, a newly implemented deep fall drawdown of a reservoir would likely result in a major effect as it alters the accumulation point of coarse sediments and exposes more shoreline and lake-bottom fine sediments to potential movement. The deep fall drawdown operation would be in effect through the project life and therefor long-term in duration. Effects within the reservoir would be local to the reservoir. A smaller alteration in the rule curve, such as refill at a later calendar date, would likely be negligible or minor effects, long-term in duration and local to the reservoir.

There are no new hydraulic or sediment models (e.g., HEC-RAS) run as part of the analysis. Existing hydraulic models inform the professional engineering judgment wrapped into the qualitative levels of change listed above. Furthermore, the measures under consideration are primarily about operational changes outside of the major flood season. New potential hydraulic and sediment models would differentiate the alternatives significantly more during the high flows of the flood season, in contrast to the relatively lower-flow late spring, summer and fall.

##### *3.3.2.1.2 Storage Project Metrics*

There are eleven WVS dams that are designed and operated for flood, irrigation, or other storage purposes: Blue River, Cottage Grove, Cougar, Detroit, Dorena, Fall Creek, Fern Ridge, Foster, Green Peter, Hills Creek and Lookout Point. Note that while Foster can be operated as a run-of-river project, it also includes a small amount of storage, and thus, was also evaluated for the storage project metrics. Operators change the pool elevation at these storage projects over large ranges throughout the year to capture and release water in to meet specific water management goals.

**Shoreline Exposure**

Shoreline erosion of bank sediments along reservoir margins is a complex process that is influenced by the cumulative effects of: wind and boat wave erosion, reservoir currents, precipitation runoff, freeze-thaw, soil properties, exposure, and vegetation density and type. One commonly observed process is that, during times of extended reservoir drawdown, exposed un-vegetated shoreline soils that were previously saturated are prone to erosion and localized slope failures (slumping). The shoreline exposure metric was developed as a surrogate for shoreline erosion processes. This metric compares the number of days that the reservoir water surface spends at any elevation to identify change in shoreline exposure and indicate the potential for change in shoreline erosion in the WVS storage projects. Shoreline processes leave long-term marks on the land, reworking soils and exposing underlying layers.

The simplest metric is a reservoir elevation exceedance percentage analysis. Comparison of the reservoir elevation exceedance percentage between alternatives would demonstrate the range of reservoir operations. If the range and duration of the reservoir elevations changes, there is a potential that the shoreline erosion rates, or patterns, may change. While the shoreline exposure metric does not directly consider reservoir draft rate, it does represent the duration effects that could result from draft rate operational measures. See Appendix C, Section 1.3.1 for additional details on the shoreline exposure metric calculation and magnitude thresholds.

Shoreline exposure effects may vary in magnitude, but would be long-term, as long as the alternative operation set remains in effect, and local to the reservoir where the draft is occurring.

**Head of Storage Reservoir Sediment Mobilization**

The head-of-reservoir sediment mobilization metric is designed to indicate the potential for changes in sediment scour and deposition patterns in the most upstream portion of storage reservoirs. In dams that use large amounts of storage volume and operate over a wide range of elevations throughout the year, the transition from riverine to reservoir conditions can shift upstream and downstream considerable distances. If reservoir drawdown leaves the delta exposed during high-flow periods, the upper layers of delta would be eroded and transported further into the reservoir, potentially increasing turbidity within the reservoir and thickness of lakebed deposits. Changes in storage project elevations or changes to the flow of water and sediment into the reservoir can result in changes to the head-of-reservoir erosion and deposition patterns. This metric compares the paired relationships of flow and stage over time to indicate the potential for change in sediment mobilization at the head-of-reservoir for each alternative. Changes in delta sediment mobilization could alter the sediment load farther downstream within the reservoir and potentially the amount of sediment passing a dam, particularly during high-flow periods. See Appendix C, Section 1.3.2 for additional details on the head of reservoir sediment mobilization metric calculation and magnitude thresholds.

Head of reservoir sediment mobilization effects may vary in magnitude, but would be long-term, as long as the alternative operation set remains in effect, and local to the reservoir where the change in the metric is occurring.

**Sediment Trap Efficiency**

The sediment trap efficiency metric estimates the potential for changes in the amount of sediment that can deposit within or pass through the storage reservoirs. Trap efficiency is the proportion of inflowing sediment deposited in the reservoir relative to the total incoming sediment load. The trap efficiency is computed based on the ratio of reservoir storage volume to annual inflow. Because the volume of water stored at any given time in the storage projects can vary between alternatives, there is potential for the amount of material being deposited in the reservoir to change between alternatives. This metric compares the paired relationship of flow and reservoir storage to indicate the potential for changes in the amount of sediment being trapped by the storage projects for each action alternative relative to the NAA. The actual amount of sediment trapped is dependent not only on trap efficiency but also the incoming sediment load. See Appendix C, Section 1.3.3 for additional details on the sediment trap efficiency metric calculation and impact thresholds.

Sediment trap efficiency effects may vary in magnitude, but would be long-term, as long as the operation set remains in effect, and local to the reservoir where the change in the metric is occurring. Indirect effects of sediment being transported downstream of a dam are expressed in the run-of-river reservoir and free-flowing reach metric, potential changes in sediment supply.

#### *3.3.2.1.3 Run-of-River Reservoirs and Free-Flowing Reach Metrics*

Run-of-river reservoirs and free-flowing reaches include all the river reaches downstream of WVS storage projects. Run-of-river reservoirs are formed by dams that are operated to discharge water downstream at rates that generally match the upstream inflows. Big Cliff, and Dexter dams are run-of-river projects that operate in a small range of pool elevations for daily or weekly hydropower purposes but do not attempt to store water for release in later seasons. Foster Dam is considered both a storage and a run-of-river project in this analysis as it is partially operated to re-regulate the outflows from Green Peter. Free-flowing reaches are portions of the river downstream of WVS storage reservoirs that are not influenced by the backwater of a downstream reservoir. The run-of-river and free-flowing reach metrics are necessarily qualitative due to a lack of continuous bed material sediment data or lack of continuous and integrated hydraulic modeling.

**Potential for Change in Sediment Supply**

This metric estimates the potential for changes in sediment passing WVS projects relative to NAA. This can occur when WVS storage projects experience large changes in sediment trapping efficiency. This can also occur where there is a change in operational range of the WVS reservoirs that can potentially re-entrain sediment currently stored in the reservoir or induce slope failures and introduce new sediment to the system. This metric also addresses the gravel augmentation below dams (#384) measure where sediment supply would be actively augmented.

The sediment supply analysis assumes that sediment supply from rivers upstream of WVS projects, or tributaries to WVS impacted reaches that are not downstream of a WVS reservoir, would be unchanged relative to the NAA.

The sediment trap efficiency metric integrates coincident daily reservoir inflow with storage to estimate trapping efficiency. This calculation focuses on sediment delivered to the reservoir from the watershed with the sediment load assumed to be correlated to inflow. Decreases in sediment trapping efficiency indicate that the reservoir would have the potential to deliver more sediment downstream and is considered in the potential for change in sediment supply metric.

A separate potential source of sediment to the reservoir can come from bank erosion or bank failures within the reservoir itself. Drafts deeper than those historically experienced have the potential to re-suspend stored sediments or induce landslides (USACE 2003) introducing new sediment to the reservoir. The timing of these deep drawdowns is not correlated to reservoir inflow and are not fully captured in the sediment trap efficiency metric. Deeper drafts are assumed to increase the potential for sediment re-entrainment supplying additional suspended sediment to the reservoir. Whether this sediment would settle within the reservoir or pass downstream would depend on sediment particle size and hydraulics within the reservoir. Lacking detailed data for both factors, reduction in minimum pool storage relative to the NAA, which is coincident with drafts, is used to indicate if there is a change in potential for sediment to pass the reservoir.

Sediment augmentation though spawning gravel nourishment or geomorphic process-based sediment nourishment below target WVS projects in included in the gravel augmentation below dams (#384) measure. A direct introduction of bed material to the system would change sediment supply in a known and controlled manner.

See Appendix C, Section 1.4.1 for additional details on the potential for change in sediment supply metric calculation and magnitude thresholds.

Potential for changes in sediment supply effects may vary in magnitude, but would be long-term, as long as the alternative operation set or gravel augmentation below dams (#384) measure remains in effect. Potential for changes in sediment supply effects would be local to regional with fine grained sediments capable of passing from an upstream reach to downstream reaches. Changes in sediment supply from WVS projects due to changes in system operations are indirect effects, while gravel augmentation below dams (#384) effects would be direct.

**Potential for Geomorphic Change**

This metric estimates the potential for changes in river character due to operations proposed by the action alternatives. System wide morphological change, away from the NAA, would be dependent on changes to flood flow frequency, changes to bank stabilization, or changes in sediment supply. The Proposed Action is not proposing any measures or a suite of measures that change flood flow frequency and as such, morphologic changes or processes that are driven by high flows would be unchanged from the NAA. Measure 9, maintain revetments considering nature-based engineering or alter revetments for aquatic ecosystem restoration, does propose to implement maintenance actions that incorporate nature-based engineering options. This would locally change habitat but maintain the river stabilization purposes and geomorphic trajectory of the revetment. Also proposed in measure 9 also seeks opportunities for working with non-federal sponsors to study and work through processes for substantial alternation. These project would be brought under the Continuing Authority Program Section 1135 and would be require analysis a compliance actions consistent with the authority. While there is opportunity for localized or potentially larger geomorphologic effects due to revetment alternation, the location and scale are unknown at this time and would be analyzed for effects in future planning. The remaining actions that could impact geomorphic trends are those that change sediment supply to the system. See Appendix C, Section 1.4.2 for additional details on the potential for geomorphic change metric calculation and magnitude thresholds.

Potential for geomorphic change effects may vary in magnitude but would be long-term as geomorphic effects manifest over long periods of time and persist beyond immediate action. Potential for geomorphic change would be local to regional with change in sediment supply effecting both the immediate reach below a WVS dam and downstream reaches. Potential for geomorphic change due to changes in system operations are indirect effects, while gravel augmentation below dams (#384) effects would be direct.

#### *3.3.2.1.4 Construction*

This PEIS discusses general, qualitative effects from construction at the programmatic level. Site-specific project details for each construction measure would be determined during the implementation phase. Subsequent tiered NEPA documents would discuss detailed site-specific effects.

Direct effects to sediment supply associated with many construction activities (such as fish facility construction and revetment modifications) would include releases of fine-grained sediment during installation and removal of coffer dams, fish exclusions or water management activities. Sediment management limiting sediment releases would occur during the construction period. Following the completion of construction actions, local sediment supply would return to existing conditions.

Construction of the WTC towers at Detroit, Lookout Point, Green Peter, and Hills Creek may require reservoir drawdowns and pool restrictions over several years. A long drawdown may also be necessary at Cougar to construct the outlet works for the routine use of the diversion tunnel. During the construction activities, a lower pool at each of these reservoirs would mean notably reduced conservation season water storage. In the winter, each reservoir could be subject to pool restrictions over the construction period, which may impact flood risk management operations. Deeper reservoir drafts have the potential change head of reservoir sediment deposition patterns and mobilize stored sediment within the reservoir, increasing suspended sediment concentrations within and downstream of the reservoir. Winter pool restrictions would have the potential to decrease sediment trapping efficiency of the reservoir, increasing fine-grained sediment releases from the stage restricted reservoirs during high flow winter events.

#### *3.3.2.1.5 Climate Change*

Supplemental Climate Change Information- Appendix F2 and Willamette Basin Climate Change Qualitative Assessment-Appendix F1, describe projected climate change trends likely to be experienced in the WVS. The supplemental appendix also identifies relevant climate factors or hydrology and climate variables that may change and have a consequential impact to the PEIS resource areas. The climate change factors of most importance to the hydraulics resource area are projected future changes in precipitation (rainfall and snow), rates of peak and average streamflow, snowpack and flow volumes, and wildfire intensity/frequency.

There is a causal relationship between wildfires and increased sediment supply observed in the Pacific Northwest and elsewhere. The dominant processes for increased supply in the Pacific Northwest are dry ravel in the short-term following fire and hillslope failure with associated debris flows in the longer-term (Alden Research Laboratory Inc. 2021). Ravel occurs when wildfires disturb or eliminate vegetation and other organic structures that hold loose material on steep slopes. This material can lead to debris flows during the wet season in the Pacific Northwest as material collected in valley and channel bottoms is moved downstream during high peak flow events. Hillslope failure is exacerbated in the years post wildfire by the loss of shear strength in the soils as tree roots decay, typically 5-10 years post-fire (Wondzell and King 2003Surface erosion and shallow channels cut into the soil by the erosive action of flowing water (rilling) during direct runoff in a minor factor in sediment supply changes in the Pacific Northwest due to low rainfall intensity and high infiltration rates (Alden Research Laboratory Inc. 2021). Increases in annual very high fire danger days are assumed to be directly related to an increase in acres burned by severe forest fires, and therefore, an increase in basin sediment supply, particularly in portions of the basin with steeper topography.

Sediment transport and many geomorphic processes associated with river and streams are dominated by high flows and associated high energies in the river. Changes in peak flows or changes in the duration of high flow can both increase the sediment transport capability of a river and increase the potential for larger scale geomorphic change (such as bar growth, bank erosion or avulsions). It is assumed that higher peak flows or longer durations of high flow are correlated to increases in sediment transport and geomorphic change. With the presence of flood storage projects that can trap sediment and regulate peak flood flows in the basin, the expected changes in the regulated reaches would be largely mitigated. Unregulated rivers and would more directly show the potential sediment supply, transport and geomorphic changes associated with climate change.

These climate change factors as well as the climate change analysis performed in the Hydrologic Processes, section 3.2, were used to qualitatively assess the expected effects to the system under NAA and all Alternatives.

#### *3.3.2.2 No Action Alternative*

Environmental consequences under the NAA are defined as the geomorphology and sediment transport conditions that would be expected within the WVS study area, without any changes in system configuration, maintenance, or operation. For this NAA assessment, future geomorphology and sediment transport conditions are evaluated for the next 30 years. River mechanics metrics related to the NAA are generally described below from a process-based perspective.

Under the NAA, climatic conditions, land use patterns, and the amount of sediment entering the reservoirs from upstream are all expected to remain the same as historically experienced. Climatic conditions, land use, and precipitation are major drivers for sediment erosion and yield into the river system. The range of precipitation is expected to be within the historical range experienced, including some very wet and some very dry years. Land use is anticipated to follow similar patterns as currently experienced, with discrete population centers in some areas, but with a large portion of the watershed held as public lands. Sources of sediment such as agricultural fields are expected to continue cultivation in a manner similar to the current conditions. Under the NAA, the sediment loading throughout the basin is not expected to change from the historical range experienced.

Under the NAA, water storage patterns are expected to be generally within the same range as historically experienced. There is a wide range in the water elevation in the storage reservoirs depending on the season and precipitation, and this variation would continue to control the location of the transition between riverine and reservoir conditions. The flow rates and project operating stages within the system are expected to remain within the historical range of variations. The incoming flow rate and downstream stage within a river segment or reservoir directly affect the hydraulic grade, which is the primary driver of sediment transport and suspension.

Shoreline erosion occurs to varying degrees in the storage reservoirs, depending on water level, wind (wave erosion), ice, currents, and other processes. Under the NAA, the duration and timing of reservoir water levels are not expected to change compared to the historical range. Similarly, it is anticipated that winds, freeze-thaw patterns, and flow rates within the reservoir would be within the historically experienced range.

Sediment would continue to deposit at the head of reservoirs (deltas) due to the slow-velocity backwater zone caused by the dams. Erosion and transport of head of reservoir sediment is expected to continue as a result of fluctuating reservoir pools. The transport of sediment from the head of the reservoir (delta) further downstream are expected to remain within the historically experienced range.

Reservoirs would continue to trap incoming sediment due to the slow-velocity backwater pool created by the dams. The amount of sediment trapped in storage reservoirs is expected to be within historical levels, since the reservoir operations and sediment loading are not expected to change. A portion of the incoming sediment load would continue to pass run-of-river reservoirs and free-flowing reaches at magnitudes and rates similar to those historically experienced.

Bed material erosion and deposition patterns, bank erosion and avulsion rates and overall geomorphic character would continue to be altered by the WVS, since flow rates, operational stages, and sediment loading to the system are expected to be similar to historical ranges. Federal revetments would continue to function to limit bank erosion and avulsion. Rates of change and process would continue as described in the affected environment. Deposition and finer bed-material gradation in run-of-river reservoir downstream of storage projects is expected to continue in areas backwatered by dams.

##### *3.3.2.2.1 Lower Willamette*

**Run-of-River Reservoir and Free-Flowing Reaches**

Under the NAA in the Lower Willamette, negligible change is expected in the run-of-river reservoir and free-flowing reach metrics for potential changes in sediment supply or geomorphic change, indicating that these processes would continue at magnitudes and rates similar to those described in the Affected Environment (Sections 3.3.1.3 and 3.3.1.4). The negligible change in these metrics results from negligible change in flow rates, operating levels, hydraulic regime, sediment sources and loading, and sediment properties while the operations stay unchanged.

##### *3.3.2.2.2 Middle Willamette*

**Run-of-River Reservoir and Free-Flowing Reaches**

Under the NAA in the Middle Willamette, negligible change is expected in the run-of-river reservoir and free-flowing reach metrics for potential changes in sediment supply or geomorphic change, indicating that these processes would continue at magnitudes and rates similar to those described in the Affected Environment (Sections 3.3.1.3 and 3.3.1.5). The negligible change in these metrics results from negligible change in flow rates, operating levels, hydraulic energy regime, sediment sources and loading, and sediment properties.

##### *3.3.2.2.3 Upper Willamette*

**Run-of-River Reservoir and Free-Flowing Reaches**

Under the NAA in the Upper Willamette, negligible change is expected in the run-of-river reservoir and free-flowing reach metrics for potential changes in sediment supply or geomorphic change, indicating that these processes would continue at magnitudes and rates similar to those described in the Affected Environment (Sections 3.3.1.3 and 3.3.1.6). The negligible change in these metrics results from negligible change in flow rates, operating levels, hydraulic energy regime, sediment sources and loading, and sediment properties.

##### *3.3.2.2.4 North Santiam*

**Storage Projects – Detroit Dam**

Under the NAA in Detroit Reservoir, negligible change is expected in storage project metrics for head of reservoir sediment mobilization, trap efficiency, and shoreline exposure, indicating that these processes would continue as generally described in the Affected Environment (Section 3.3.1.3). The negligible change in these metrics results from negligible change in water storage patterns, seasonal reservoir elevations, sediment loading, and sediment properties.

**Run-of-River Reservoir and Free-Flowing Reaches**

Under the NAA in the North Santiam, negligible change is expected in the run-of-river reservoir and free-flowing reach metrics for potential changes in sediment supply or geomorphic change, indicating that these processes would continue at magnitudes and rates similar to those described in the Affected Environment (Sections 3.3.1.3 and 3.3.1.7). The negligible change in these metrics results from negligible change in flow rates, operating levels, hydraulic energy regime, sediment sources and loading, and sediment properties.

#### *3.3.2.2.5 South Santiam and Mainstem Santiam*

**Storage Projects – Green Peter and Foster**

Under the NAA in Green Peter and Foster reservoirs, negligible change is expected in Storage Project metrics for head of reservoir sediment mobilization, trap efficiency, and shoreline exposure, indicating that these processes would continue as generally described in the Affected Environment (Section 3.3.1.3). The negligible change in these metrics results from negligible change in water storage patterns, seasonal reservoir elevations, sediment loading, and sediment properties.

**Run-of-River Reservoir and Free-Flowing Reaches**

Under the NAA in the South Santiam and Mainstem Santiam, negligible change is expected in the run-of-river reservoir and free-flowing reach metrics for potential changes in sediment supply or geomorphic change, indicating that these processes would continue at magnitudes and rates similar to those described in the Affected Environment (Sections 3.3.1.3 and 3.3.1.8). The negligible change in these metrics results from negligible change in flow rates, operating levels, hydraulic energy regime, sediment sources and loading, and sediment properties.

#### *3.3.2.2.6 Long Tom River*

**Storage Projects – Fern Ridge**

Under the NAA in Fern Ridge Reservoir, negligible change is expected in storage project metrics for head of reservoir sediment mobilization, trap efficiency, and shoreline exposure, indicating that these processes would continue as generally described in the Affected Environment (Section 3.3.1.3). The negligible change in these metrics results from negligible change in water storage patterns, seasonal reservoir elevations, sediment loading, and sediment properties.

**Run-of-River Reservoir and Free-Flowing Reaches**

Under the NAA in the Long Tom, negligible change is expected in the run-of-river reservoir and free-flowing reach metrics for potential changes in sediment supply or geomorphic change, indicating that these processes would continue at magnitudes and rates similar to those described in the Affected Environment (Sections 3.3.1.3 and 3.3.1.9). The negligible change in these metrics results from negligible change in flow rates, operating levels, hydraulic energy regime, sediment sources and loading, and sediment properties.

#### *3.3.2.2.7 McKenzie and Blue Rivers*

**Storage Projects – Cougar and Blue River**

Under the NAA in Cougar and Blue River reservoirs, negligible change is expected in storage project metrics for head of reservoir sediment mobilization, trap efficiency, and shoreline exposure, indicating that these processes would continue as generally described in the Affected

Environment (Section 3.3.1.3). The negligible change in these metrics results from negligible change in water storage patterns, seasonal reservoir elevations, sediment loading, and sediment properties.

**Run-of-River Reservoir and Free-Flowing Reaches**

Under the NAA in the McKenzie and Blue River, negligible change is expected in the run-of-river reservoir and free-flowing reach metrics for potential changes in sediment supply or geomorphic change, indicating that these processes would continue at magnitudes and rates similar to those described in the Affected Environment (Sections 3.3.1.3 and 3.3.1.10). The negligible change in these metrics results from negligible change in flow rates, operating levels, hydraulic energy regime, sediment sources and loading, and sediment properties.

##### *3.3.2.2.8 Middle Fork of the Willamette River and Fall Creek*

**Storage Projects – Fall Creek, Lookout Point and Hills Creek**

Under the NAA in Fall Creek, Lookout Point and Hills Creek reservoirs, negligible change is expected in storage project metrics for head of reservoir sediment mobilization, trap efficiency, and shoreline exposure, indicating that these processes would continue as generally described in the Affected Environment (Section 3.3.1.3). The negligible change in these metrics results from negligible change in water storage patterns, seasonal reservoir elevations, sediment loading, and sediment properties.

**Run-of-River Reservoir and Free-Flowing Reaches**

Under the NAA in the Middle Fork of the Willamette and Fall Creek, negligible change is expected in the run-of-river reservoir and free-flowing reach metrics for potential changes in sediment supply or geomorphic change, indicating that these processes would continue at magnitudes and rates similar to those described in the Affected Environment (Sections 3.3.1.3 and 3.3.1.11). The negligible change in these metrics results from negligible change in flow rates, operating levels, hydraulic energy regime, sediment sources and loading, and sediment properties.

##### *3.3.2.2.9 Coast Fork of the Willamette River and Row Rivers*

**Storage Projects – Cottage Grove and Dorena**

Under the NAA in Cottage Grove and Dorena reservoirs, negligible change is expected in storage project metrics for head of reservoir sediment mobilization, trap efficiency, and shoreline exposure, indicating that these processes would continue as generally described in the Affected Environment (Section 3.3.1.3). The negligible change in these metrics results from negligible change in water storage patterns, seasonal reservoir elevations, sediment loading, and sediment properties.

**Run-of-River Reservoir and Free-Flowing Reaches**

Under the NAA in the Coast Fork of the Willamette, negligible change is expected in the run-of-river reservoir and free-flowing reach metrics for potential changes in sediment supply or geomorphic change, indicating that these processes would continue at magnitudes and rates similar to those described in the Affected Environment (Sections 3.3.1.3 and 3.3.1.12). The negligible change in these metrics results from negligible change in flow rates, operating levels, hydraulic energy regime, sediment sources and loading, and sediment properties.

*3.3.2.2.10 Climate Change*

Site specific variation is described in the climate change technical appendices (F1 and F2). However, the following climate trends are applicable to the wider WRB. Temperatures in the region are expected to warm relative to the historic period 1970-1999 by another 1.5 to 3 deg F by about mid-century and 2 to 5 deg F by the end. Already scarce winter snowpack is likely to decline over time as more winter precipitation falls as rain instead of snow. The projections are for future precipitation to trend upward for the rest of the century, particularly in the winter months. Already dry summers could become drier. Overall, the climate change assessments point to fall and winter flows likely increasing.

Additionally, the number of days with very high fire danger in any given year are projected to increase in all of the WVS subregions. Supplemental Climate Change Information Appendix F2 shows a consistent trend across all WVS subbasins, with a projected increase in median "Annual Very High Fire Danger Day" from 36 days in 1971-2020 to 49 days by 2040-2069. This increase in fire danger days is expected to correlate to increased land area impacted by wildfire and increased sediment supply from dry ravel, slope failure, and debris flows as described in Section 3.3.1.3.

The transition toward increased wintertime flow volumes, and potentially flood magnification, along with reduced snowpack and increased potential for wildfires, create the conditions for increased sediment supply to the Willamette River and its tributaries. Sediment transport throughout the system is correlated with flow, with higher flows moving more sediment. However, sediment must be available to the river for it to be transported. Sediment supply, for both coarse- and fine-grained sediment, is expected to increase generally in the system due to reduction in snow cover, which protects lands from erosion and wildfires that further destabilize soil and slopes. Morphological change, in the forms of bed and bank erosion, deposition, or even avulsion, is dominated by flood hydraulics. The potential for increase flood magnitude, along with increased sediment supply, increases the potential for morphological change.

The WVS dams would continue to trap sediment and effectively trap all coarse-grained material (with the exception of Fall Creek which currently experiences run-of-river depth drafts) and a large proportion of the fine-grained sediment. The volume of trapped sediment would likely increase under climate change but is not expected to change the flood storage volume of the system through deposition. Additional coarse sediment supplied to the reservoirs would predominately deposit at the head of reservoir while the fine sediment would distribute throughout the reservoir.

Turbidity in the system would likely increase as unregulated streams experience increased sediment supply; however, the WVS dams would continue to moderate peak suspended sediment concentrations in the regulated reaches downstream from the dams due to continued high rates of sediment trapping.

Flood regulation is expected to continue at similar magnitudes, effectively reducing peak flows downstream of the WVS projects. Morphological trends related to dam operations in the system are expected to be minorly effected from non-climate change scenarios. Unregulated steams may increase winter flow and sediment supply to the system under climate change, resulting in moderate effects with more dynamic morphology, particularly at unregulated tributary confluences.

##### *3.3.2.2.11 Summary of Effects of the No Action Alternative*

Under the NAA, negligible change is expected in storage project metrics for head of reservoir sediment mobilization, trap efficiency, and shoreline exposure, indicating that these processes would continue as generally described in the Affected Environment throughout the WVS. The negligible effect results from negligible change in water storage patterns, seasonal reservoir elevations, sediment loading, and sediment properties.

Negligible change is expected in the run-of-river reservoir and free-flowing reach metrics for potential changes in sediment supply or geomorphic change, indicating that these processes would continue at magnitudes and rates similar to those described in the Affected Environment. The negligible effect results from negligible change in flow rates, operating levels, hydraulic energy regime, sediment sources and loading, and sediment properties.

#### ***3.3.2.3 Alternative 1***

See Section 2.4.3 for a complete description of Alternative 1. Alternative 1 effects would be relative to the NAA and are summarized by impact type in this section. See Appendix C, Chapter 2 for metric calculations and supporting figures.

##### *3.3.2.3.1 Lower Willamette*

**Run-of-River Reservoir and Free-Flowing Reaches**

There is negligible potential for changes in sediment supply relative to the NAA in the Lower Willamette free-flowing reach. There is negligible potential for geomorphic change relative to the NAA in the Lower Willamette free-flowing reach.

#### *3.3.2.3.2 Middle Willamette*

**Run-of-River Reservoir and Free-Flowing Reaches**

There is negligible potential for changes in sediment supply relative to the NAA in the Middle Willamette free-flowing reach. There is negligible potential for geomorphic change relative to the NAA in the Middle Willamette free-flowing reach.

#### *3.3.2.3.3 Upper Willamette*

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a minor change in sediment supply with additional fine-grained sediment passing into the Upper Willamette free-flowing reach from the Coast Fork Willamette when compared to the NAA. Increased sediment supply would be due to deeper drafts in Cottage Grove and Dorena reservoirs that have the potential to induce bank erosion, and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume.

There is negligible potential for geomorphic change relative to the NAA in the Upper Willamette free-flowing reach.

#### *3.3.2.3.4 North Santiam*

**Storage Projects – Detroit Dam**

Alternative 1 would have negligible change in the potential for head-of-reservoir sediment mobilization and sediment trap efficiency at Detroit Reservoir compared to the NAA. Alternative 1 would have a major change in shoreline exposure relative to NAA at Detroit Reservoir due to changes in operational range. Deeper drafts would expose additional shoreline to potential bank erosion and sediment entrainment. Deeper drafts would also allow access to reservoir banks that were previously inundated.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a moderate change in sediment supply with additional fine-grained sediment passing into Big Cliff run-of river reservoir compared to the NAA. Increased sediment supply is due to deeper drafts in Detroit Reservoir increasing the potential for bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume. These additional fine-grained sediments that enter Big Cliff Reservoir may partially settle in the reservoir.

There would be a major change in coarse-grained bed material sediment supply to the North Santiam free-flowing reach due to direct placement of bed material sized sediment through an adaptively managed sediment nourishment program compared to the NAA. Additionally, there is potential for a minor change in fine-grained sediment supply to the North Fork Santiam River downstream of Big Cliff Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply would be due to deeper drafts in Detroit Reservoir that have the potential to pass sediment through Detroit Dam and partially through the Big Cliff run-of-river reservoir.

***Geomorphic Change Below Big Cliff***

There is major potential for geomorphic change in the North Santiam downstream of Big Cliff Dam due to the gravel augmentation below dams (#384) measure as compared to the NAA. Sediment augmentation into the North Santiam River below Big Cliff Dam is proposed to improve the quality and quantity of habitat for Spring Chinook and Winter Steelhead. The North Santiam below Big Cliff has been largely scoured of appropriately sized spawning gravels and has developed an armored bed between bedrock grade control. Gravel augmentation below dams (#384) would annually place an appropriate quantity of specifically sized and graded sediments into the river prior to seasonal high flows and spawning. The placed material would be distributed by the river during high flows into bank attached bars and bed patches and would transiently fill existing pools. This sediment augmentation would likely deposit on top of existing armored river features and be mobile during high water events and water years, with gravels scouring and cleaning themselves as they pulse downstream.

Since the North Santiam River is capable of scouring out these size classes of sediment and armoring its bed in the existing condition, placed gravel would be expected to transport, abrade to smaller material, and deposit for longer term storage in bars and backwaters over time. An ongoing program of annual or semiannual sediment placement is proposed to maintain long term spawning gravel bars and beds downstream of the dam.

Placed sediment would be screened for only bed material, therefore transport rates and distances would be limited in any given water year. Gravel pulses are expected to transport downstream at a rate of approximately 1 mile per year as observed in the long running gravel augmentation project below Howard Hansen Dam in the Green River (USACE 2018).

Sediment placement would partially fill the channel and replace a portion of the sediment that has scoured since Dam development and regulation. Channel aggradation, to the extent that it occurs, is based on sediment augmentation quantity and sizing. It is expected that aggradation would occur as bed material pulses move downstream and becomes quasi-stable as augmentation sediment is scoured and replaced in roughly the same quantities. Flood capacity of the channel may be impacted by placed sediments, however the placed sediment and resulting transient river features are only expected to replace a portion of historical sediment that has scoured from the river.

River condition and water surface monitoring, along with gravel augmentation below dams (#384) that may change the quantity, size or injection location of sediment augmentation, would identify and respond to river changes to improve targeted river feature creation and limit adverse effects.

#### *3.3.2.3.5 South Santiam and Mainstem Santiam*

**<u>Storage Projects – Green Peter and Foster</u>**

Alternative 1 would have negligible change in the potential for head-of-reservoir sediment mobilization and sediment trap efficiency at Green Peter and Foster reservoirs as compared to the NAA. Alternative 1 would have a negligible change in shoreline exposure relative to NAA at Foster Reservoir.

Alternative 1 would have a major change in shoreline exposure relative to NAA at Green Peter Reservoir due to changes in operational range. Deeper drafts would expose additional shoreline to potential bank erosion and sediment entrainment. Deeper drafts would also allow access to reservoir banks that were previously inundated under the NAA.

**<u>Run-of-River Reservoir and Free-Flowing Reaches</u>**

There is potential for a moderate change in sediment supply with additional fine-grained sediment passing into Foster Reservoir as compared to the NAA. Increased sediment supply is due to deeper drafts in Green Peter Reservoir increasing the potential for bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume. These additional fine-grained sediments that enter Foster Reservoir may partially settle in the reservoir.

There is a major change in coarse-grained bed material sediment supply to the South Santiam free-flowing reach due to direct placement of bed material sized sediment through gravel augmentation below dams (#384) as compared to the NAA. Additionally, there is potential for a minor change in fine-grained sediment supply to the South Fork Santiam River downstream of Foster Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply is due deeper drafts in Green Peter Reservoir that have the potential to pass sediment through Green Peter Dam and partially through Foster Reservoir.

***Geomorphic Change Below Foster Dam***

There is major potential for geomorphic change in the South Santiam downstream of Foster Dam due to the gravel augmentation below dams (#384) measure as compared to the NAA. Sediment augmentation into the South Santiam River below Foster Dam is proposed to improve the quality and quantity of habitat for Spring Chinook and Winter Steelhead. The South Santiam below Foster has been largely scoured of appropriately sized spawning gravels and has developed an armored bed between bedrock grade control. Gravel augmentation below dams (#384) would annually place an appropriate quantity of specifically sized and graded sediments into the river prior to seasonal high flows and spawning. The placed material would be distributed by the river during high flows into bank attached bars and bed patches and would transiently fill existing pools. This sediment augmentation would likely deposit on top of existing armored river features and be mobile during high water events and water years, with gravels scouring and cleaning themselves as they pulse downstream.

Since the South Santiam River is capable of scouring out these size classes of sediment and armor its bed in the existing condition, placed gravel would be expected to transport, abrade to smaller material, and deposit for longer term storage in bars and backwaters over time. An ongoing program of annual or semiannual sediment placement is proposed to maintain long term spawning gravel bars and beds downstream of the Dam.

Placed sediment would be screened for only bed material, therefor transport rates and distances would be limited in any given water year. Gravel pulses are expected to transport downstream at a rate of approximately 1 mile per year as observed in the long running gravel augmentation project below Howard Hansen Dam in the Green River (USACE 2018a).

Sediment placement would partially fill the channel and replace a portion of the sediment that has scoured since Dam development and regulation. Channel aggradation, to the extent that it occurs, is based on sediment augmentation quantity and sizing. It is expected that aggradation would occur as bed material pulses move downstream and then become quasi-stable as augmentation sediment is scoured and replaced in roughly the same quantities. Flood capacity of the channel may be impacted by placed sediments, however the placed sediment and resulting transient river features are only expected to replace a portion of historical sediment that has scoured from the river.

River condition and water surface monitoring, along with gravel augmentation below dams (#384) that may change the quantity, size or injection location of sediment augmentation, would identify and respond to river changes to improve targeted river feature creation and limit adverse effects.

##### *3.3.2.3.6 Long Tom River*

**Storage Projects – Fern Ridge**

Alternative 1 would have negligible change in the potential for shoreline exposure, head-of-reservoir sediment mobilization and sediment trap efficiency at Fern Ridge Reservoir as compared to the NAA.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is negligible potential for changes in sediment supply relative to the NAA in the Long Tom River free-flowing reach. There is negligible potential for geomorphic change relative to the NAA in the Long Tom River free-flowing reach.

##### *3.3.2.3.7 McKenzie and Blue Rivers*

**Storage Projects – Cougar and Blue River**

Alternative 1 would have major changes in shoreline exposure relative to NAA due to changes in operational range at Cougar and Blue River reservoirs. Deeper drafts expose additional shoreline to potential bank erosion, sediment entrainment or even slope failures. Deeper drafts also allow access to banks that were previously inundated.

Alternative 1 would have negligible potential for changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Cougar and Blue River reservoirs.

Alternative 1 would have negligible potential for changes in sediment trap efficiency relative to NAA at Cougar and Blue River reservoirs.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is a major change in coarse-grained bed material sediment supply to the McKenzie River free-flowing reach below Cougar Dam due to direct placement of bed material sized sediment through gravel augmentation below dams (#384) as compared to the NAA. Additionally, there is potential for a minor change compared to the NAA in fine-grained sediment supply to the McKenzie River downstream of Cougar Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply is due deeper drafts in Cougar Reservoir increasing the potential for bank erosion and sloughing generating sediment in the reservoir that may pass the dam due to a concurrent reduction in reservoir storage volume.

There is a major change in coarse-grained bed material sediment supply to the Blue River free-flowing reach below Blue River Dam due to direct placement of bed material sized sediment through gravel augmentation below dams (#384) as compared to the NAA. Additionally, there is potential for a moderate change compared to the NAA in fine-grained sediment supply to the Blue River downstream of Blue River Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply is due deeper drafts in Blue River Reservoir increasing the potential for bank erosion and sloughing generating sediment in the reservoir that may pass the dam due to a concurrent reduction in reservoir storage volume.

***Geomorphic Change Below Cougar Dam***

There is major potential for geomorphic change in the South Fork McKenzie downstream of Cougar Dam due to the gravel augmentation below dams (#384) measure as compared to the NAA. Sediment augmentation in the South Fork McKenzie River below Cougar Dam is proposed to maintain and enhance the existing high quality and quantity of habitat for Spring Chinook and Winter Steelhead developed in the reach since 2018. Gravel augmentation below dams (#384) would annually place an appropriate quantity of specifically sized and graded sediments into the river prior to seasonal high flows and spawning. The placed material would be distributed by the river during high flows and integrate itself into the existing anastomosing mosaic downstream established during prior river restoration activities. Sediments are expected to move slowly through the restoration reach and potentially store for longer periods of time as normative river process occur.

Because the armored plane bed condition of the river has already been addressed by restoration actions, the goal of the augmentation is to supply required sediment into an existing process-based floodplain reengagement action. The gradation classes of the augmentation would necessarily be more varied and smaller than a typical confined valley spawning gravel augmentation project.

River condition monitoring, along with gravel augmentation below dams (#384) that may change the quantity, size or injection location of sediment augmentation, would identify and respond to river changes to improve targeted habitat maintenance goals and limit adverse effects.

***Geomorphic Change Below Blue River Dam***

There is major potential for geomorphic change compared to the NAA in the Blue River and potentially in the mainstem McKenzie downstream of Blue River Dam due to the gravel augmentation below dams (#384) measure. Sediment augmentation into the Blue River below Blue River Dam is proposed to improve the quality and quantity of habitat for Spring Chinook and Winter Steelhead. The Blue River below the dam has been largely scoured of appropriately sized spawning gravels and has developed an armored bed between bedrock grade control. Gravel augmentation below dams (#384) would annually place an appropriate quantity of specifically sized and graded sediments into the river prior to seasonal high flows and spawning. The placed material would be distributed by the river during high flows into bank attached bars and bed patches and would transiently fill existing pools. This sediment augmentation would likely deposit on top of existing armored river features and be mobile during high water events and water years, with gravels scouring and cleaning themselves as they pulse downstream.

Since the South Santiam River and sediment starved reaches of the McKenzie are capable of scouring out these size classes of sediment and armor their bed in the existing condition, placed gravel would be expected to transport, abrade to smaller material, and deposit for longer term storage in bars and backwaters over time. An ongoing program of annual or semiannual sediment placement is proposed to maintain long term spawning gravel bars and beds downstream of the Dam.

Placed sediment would be screened for only bed material, therefor transport rates and distances would be limited in any given water year. Gravel pulses are expected to transport downstream at a rate of approximately 1 mile per year as observed in the long running gravel augmentation project below Howard Hansen Dam in the Green River (USACE 2018a). Due to the relatively short length of the Blue River below the dam, augmentation is expected to work its way into the mainstem McKenzie within a few years of initiation.

Sediment placement would partially fill the channel and replace a portion of the sediment that has scoured since Dam development and regulation. Channel aggradation, to the extent that it occurs, is based on sediment augmentation quantity and sizing. It is expected that aggradation would occur as bed material pulses move downstream and then become quasi-stable as augmentation sediment is scoured and replaced in roughly the same quantities. Flood capacity of the channel may be impacted by placed sediments, however the placed sediment and resulting transient river features are only expected to replace a portion of historical sediment that has scoured from the river.

River condition and water surface monitoring, along with gravel augmentation below dams (#384) that may change the quantity, size or injection location of sediment augmentation, would identify and respond to river changes to improve targeted river feature creation and limit adverse effects.

##### *3.3.2.3.8 Middle Fork of the Willamette River and Fall Creek*

**Storage Projects – Fall Creek, Lookout Point and Hills Creek**

Alternative 1 would have a negligible change in shoreline exposure relative to NAA at Fall Creek Reservoir as compared to the NAA. Alternative 1 would have a major change in shoreline exposure relative to NAA at Lookout Point and Hills Creek reservoirs due to changes in operational range. Deeper drafts expose additional shoreline to potential bank erosion and sediment entrainment. Deeper drafts also allow access to reservoir banks that were previously inundated.

Alternative 1 would have negligible potential for changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Fall Creek, Hills Creek and Lookout Point reservoirs.

Alternative 1 would have negligible potential for changes in sediment trap efficiency relative to NAA at Fall Creek, Hills Creek and Lookout Point reservoirs.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a moderate change in sediment supply with additional fine-grained sediment passing out of Hills Creek dam into the Middle Fork of the Willamette above Lookout Point Reservoir free-flowing reach as compared to the NAA. Increased sediment supply is due deeper drafts that have the potential to induce bank erosion and pass fine-grained sediment out of Hills Creek Dam. This fine-grained sediment is expected to pass into Lookout Point Reservoir and deposit.

There is potential for a minor change compared to the NAA in sediment supply with additional fine-grained sediment passing into Dexter run-of-river reservoir. Increased sediment supply is due to deeper drafts in Lookout Point Reservoir increasing the potential for bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume. These additional fine-grained sediments that enter Dexter Reservoir may settle in the reservoir.

There is negligible potential for change in sediment supply downstream of Dexter Dam.

There is negligible potential for geomorphic change relative to the NAA in the Middle Fork of the Willamette River and Fall Creek free-flowing reach.

*3.3.2.3.9 Coast Fork of the Willamette River and Row River*

**Storage Projects – Cottage Grove and Dorena**

Alternative 1 would have a major change in shoreline exposure relative to NAA at Cottage Grove and Dorena reservoirs due to changes in operational range. Deeper drafts expose additional shoreline to potential bank erosion and sediment entrainment. Deeper drafts also allow access to reservoir banks that were previously inundated.

Alternative 1 would have negligible change in the potential for head-of-reservoir sediment mobilization and sediment trap efficiency at Cottage Grove and Dorena reservoirs as compared to the NAA.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a moderate change in sediment supply with additional fine-grained sediment passing into the Coast Fork Willamette and Row River free-flowing reaches from Cottage Grove and Dorena River as compared to the NAA. Increased sediment supply is due deeper drafts in Cottage Grove and Dorena reservoirs that have the potential to induce bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume.

There is negligible potential for geomorphic change relative to the NAA in the Coast Fork of the Willamette River and Row River free-flowing reach.

*3.3.2.3.10 Climate Change*

Alternative 1 would have negligible potential for change in sediment conditions due to climate change relative to the NAA.

*3.3.2.3.11 Summary of Effects of Alternative 1*

Table 3.3-2 shows the summary of effects under Alternative 1.

**Table 3.3-2. Summary of effects for River Mechanics and Geomorphology under Alternative 1 as Compared to the NAA**

| Subbasin | Alternative 1 |
|---|---|
| **General** | Effects to river mechanics and geomorphology metrics are none/negligible except those stated below. |
| **Santiam Subbasin** | Detroit and Green Peter storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts.<br><br>Downstream of the storage projects, there is potential for a moderate effects with an increase in fine grained sediment supply |

| | |
|---|---|
| | into the Big Cliff and Foster re-regulation projects which in turn may pass a minor increase in fine grained sediment downstream into the free-flowing reaches.<br><br>Gravel augmentation below dams (#384) measure will have major effects to geomorphology downstream of Big Cliff and Foster dams and would modify the geomorphology of the North Fork Santiam and South Fork Santiam respectively. |
| **Long Tom Subbasin** | Negligible effects |
| **McKenzie Subbasin** | Cougar and Blue River storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts.<br><br>Downstream of the storage projects, there is potential for a minor effects with an increase in fine grained sediment supply into the South Fork McKenzie and a moderate increase of fine-grained sediment supply into Blue River.<br><br>Gravel augmentation below dams (#384) measure would have major effects to geomorphology downstream of the South Fork McKenzie and Blue River dams and would modify the geomorphology of the South Fork McKenzie and Blue River respectively. |
| **Middle Fork of the Willamette Subbasin** | Hills Creek and Lookout Point storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts.<br><br>Downstream of the storage projects, there is potential for a moderate effects with an increase in fine grained sediment supply below Hills Creek and a minor increase in fine-grained sediment supply below Lookout Point entering Dexter Reservoir. |
| **Coast Fork of the Willamette Subbasin** | Dorena and Cottage Grove storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts.<br><br>Downstream of both storage projects, there is potential for a moderate effect with an increase in fine grained sediment supply into the Row River and Coast Fork Willamette. |
| **Mainstem Willamette River** | Negligible effects |

### 3.3.2.4 Alternative 2A

See Section 2.4.4 for a complete description of Alternative 2A. Alternative 2A effects are relative to the NAA and are summarized by impact type in this section. See Appendix C, Chapter 2 for metric calculations and supporting figures.

#### *3.3.2.4.1 Lower Willamette*

**Run-of-River Reservoir and Free-Flowing Reaches**

There would be negligible potential for changes in sediment supply relative to the NAA in the Lower Willamette free-flowing reach. There is negligible potential for geomorphic change relative to the NAA in the Lower Willamette free-flowing reach.

#### *3.3.2.4.2 Middle Willamette*

**Run-of-River Reservoir and Free-Flowing Reaches**

There is negligible potential for changes in sediment supply relative to the NAA in the Middle Willamette free-flowing reach. There is negligible potential for geomorphic change relative to the NAA in the Middle Willamette free-flowing reach.

#### *3.3.2.4.3 Upper Willamette*

**Run-of-River Reservoir and Free-Flowing Reaches**

There is negligible potential for changes in sediment supply relative to the NAA in the Upper Willamette free-flowing reach. There is negligible potential for geomorphic change relative to the NAA in the Upper Willamette free-flowing reach.

#### *3.3.2.4.4 North Santiam*

**Storage Projects – Detroit Dam**

Alternative 2A would have negligible change in the potential for head-of-reservoir sediment mobilization and sediment trap efficiency at Detroit Reservoir as compared to the NAA. Alternative 2A would have a major change in shoreline exposure relative to NAA at Detroit Reservoir due to changes in operational range. Deeper drafts expose additional shoreline to potential bank erosion and sediment entrainment. Deeper drafts also allow access to reservoir banks that were previously inundated.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a moderate change in sediment supply with additional fine-grained sediment passing into Big Cliff run-of river reservoir as compared to the NAA. Increased sediment supply is due to deeper drafts in Detroit Reservoir increasing the potential for bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume. These additional fine-grained sediments that enter Big Cliff Reservoir may partially settle in the reservoir.

There is a major change compared to the NAA in coarse-grained bed material sediment supply to the North Santiam free-flowing reach due to direct placement of bed material sized sediment through gravel augmentation below dams (#384). Additionally, there is potential for a minor change in fine-grained sediment supply to the North Fork Santiam River downstream of Big Cliff Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply is due deeper drafts in Detroit Reservoir that have the potential to pass sediment through Detroit Dam and partially through the Big Cliff run-of-river reservoir.

***Geomorphic Change Below Big Cliff***

There is major potential for geomorphic change in the North Santiam downstream of Big Cliff Dam due to the gravel augmentation below dams (#384) measure as compared to the NAA. Geomorphic effects below Big Cliff Dam as the same as Alternative 1. See the Section 3.3.2.3.4 for description of effects.

*3.3.2.4.5 South Santiam and Mainstem Santiam*

**Storage Projects – Green Peter and Foster**

Alternative 2A would have major changes in shoreline exposure relative to NAA due to changes in operational range at Green Peter Reservoir. Deeper drafts expose additional shoreline to potential bank erosion, sediment entrainment or even slope failures. Deeper drafts also allow access to banks that were previously inundated. Alternative 2A would have negligible change in shoreline exposure at Foster Reservoir as compared to the NAA.

Alternative 2A would have the potential for a major change in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Green Peter Reservoir. There is major potential for stored head-of-reservoir sediment to be re-mobilized and transported further into the reservoir. Future head-of-reservoir deposition would likely deposit further into the reservoir than NAA. Potential changes in head-of-reservoir deposits are due to operations holding the reservoirs lower than NAA during higher inflow where sediment is mobilized and brought into the reservoir from upstream.

Alternative 2A would have the potential for minor change in head-of-reservoir sediment mobilization relative to NAA in Foster Reservoir. This is due to changes in operations at Green Peter Reservoir upstream. Peak flows entering Foster Reservoir when the pool is drawn down are decreased, however there is an increase in fall flows when the reservoir is full. There is minor potential for future head-of-reservoir deposition to occur higher in the reservoir relative to NAA.

Head-of reservoir deposits are typically composed of the coarse-grained sediment supply (sand, gravels and any cobbles that may be in transport) but may also contain some of the coarser silts that can readily settle in the transition from flowing river to quiescent reservoir.

Alternative 2A would have the potential for moderate changes in sediment trap efficiency with reduced trap efficiency relative to NAA at Green Peter Reservoir. Alternative 2A would have negligible potential for changes in sediment trap efficiency relative to NAA at Foster Reservoir. Potential changes in reservoir sediment trap efficiency in all cases are due to operations holding the reservoirs lower than NAA, resulting in sufficiently lower reservoir storage volumes, during higher inflow where sediment is mobilized and brought into the reservoir from upstream. Reductions in trap efficiency would mean that a larger fraction of easily suspended, fine-grained sediment may stay in transport and pass these dams. This results in less deposition of these fine-grained sediments in the reservoir and conversely, large quantities of easily suspended, fine-grained sediments passing the reservoir downstream.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a major change in sediment supply with additional fine-grained sediment passing into Foster reservoir as compared to the NAA. Increased sediment supply is due to deeper drafts in Green Peter Reservoir. The primary mechanism that is causing the effect determination is deeper drafts create major potential for bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume. Additionally, there is a moderate decrease in trapping efficiency at Green Peter Reservoir where the dam passes additional inflowing sediment during high flow events. These additional fine-grained sediments that enter Foster Reservoir may partially settle in the reservoir.

There is a major change, compared to the NAA, in coarse-grained bed material sediment supply to the South Santiam free-flowing reach due to direct placement of bed material sized sediment through gravel augmentation below dams (#384). Additionally, there is potential for a moderate change in fine-grained sediment supply to the South Fork Santiam River downstream of Foster Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply is due deeper drafts in Green Peter Reservoir that have the potential to pass sediment through Green Peter Dam and partially through Foster Reservoir.

There is potential for a minor change in sediment supply with additional fine-grained sediment passing into the Mainstem Santiam free-flowing reach from the both the North Fork and South Fork Santiam Rivers as compared to the NAA. Increased sediment supply is due deeper drafts in Green Peter and Detroit reservoirs that have major potential pass additional fine-grained sediment downstream of the dams.

***Geomorphic Change in Foster Run-of-River Reservoir***

Due to the potential for a major change in fine-grained sediment supply into Foster Reservoir from Green Peter draw downs, observable changes in sedimentation rates in Foster Reservoir compared to the NAA are likely. Trapping efficiency for Foster is calculated to be 67% meaning that a portion of the increased fine-grained sediment supply would likely get trapped in the reservoir. This deposition would likely appear as a thicker silt drape within the reservoir and areas along on the banks of Foster reservoir.

***Geomorphic Change Below Foster Dam***

There is major potential for geomorphic change in the South Santiam downstream of Foster Dam due the gravel augmentation below dams (#384) measure as compared to the NAA. Geomorphic effects below Foster Dam as the same as Alternative 1. See Section 3.3.2.3.5 for description of effects.

*3.3.2.4.6 Long Tom River*

**Storage Projects – Fern Ridge**

Alternative 2A would have negligible change from the NAA in the potential for shoreline exposure, head-of-reservoir sediment mobilization and sediment trap efficiency at Fern Ridge Reservoir.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is negligible potential for changes in sediment supply relative to the NAA in the Long Tom River free-flowing reach. There is negligible potential for geomorphic change relative to the NAA in the Long Tom River free-flowing reach.

*3.3.2.4.7 McKenzie and Blue Rivers*

**Storage Projects – Cougar and Blue River**

Alternative 2A would have major changes in shoreline exposure relative to NAA due to changes in operational range at Cougar and Blue River reservoirs. Deeper drafts expose additional shoreline to potential bank erosion, sediment entrainment or even slope failures. Deeper drafts also allow access to banks that were previously inundated.

Alternative 2A would have negligible potential for changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Cougar and Blue River reservoirs.

Alternative 2A would have negligible potential for changes in sediment trap efficiency relative to NAA at Cougar and Blue River reservoirs.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is a major change in coarse-grained bed material sediment supply to the McKenzie River free-flowing reach below Cougar Dam due to direct placement of bed material sized sediment through gravel augmentation below dams (#384) as compared to the NAA. Additionally, there is potential for a minor change in fine-grained sediment supply to the McKenzie River downstream of Cougar Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply is due deeper drafts in Cougar Reservoir increasing the potential for bank erosion and sloughing generating sediment in the reservoir that may pass the dam due to a concurrent reduction in reservoir storage volume.

There is a major change, compared to the NAA, in coarse-grained bed material sediment supply to the Blue River free-flowing reach below Blue River Dam due to direct placement of bed material sized sediment through gravel augmentation below dams (#384). Additionally, there is potential for a moderate change in fine-grained sediment supply to the Blue River downstream of Blue River Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply is due deeper drafts in Blue River Reservoir increasing the potential for bank erosion and sloughing generating sediment in the reservoir that may pass the dam due to a concurrent reduction in reservoir storage volume.

***Geomorphic Change Below Cougar Dam***

There is major potential for geomorphic change in the South Fork McKenzie downstream of Cougar Dam due to the gravel augmentation below dams (#384) measure as compared to the NAA. Geomorphic effects of gravel augmentation below Cougar Dam as the same as Alternative 1. See the Geomorphic Change Below Cougar Dam discussion in Alternative 1 for description of effects.

***Geomorphic Change Below Blue River Dam***

There is major potential for geomorphic change compared to the NAA in the Blue River and potentially in the mainstem McKenzie downstream of Blue River Dam due to the gravel augmentation below dams (#384) measure. Geomorphic effects of gravel augmentation below Blue River Dam as the same as Alternative 1. See Section 3.3.2.3.7 for description of effects.

#### *3.3.2.4.8 Middle Fork of the Willamette River and Fall Creek*

**<u>Storage Projects – Fall Creek, Lookout Point and Hills Creek</u>**

Alternative 2A would have negligible change relative to the NAA in shoreline exposure at Fall Creek Reservoir. Alternative 2A would have major changes in bank exposure relative to NAA due to changes in operational range at Hills Creek and Lookout Point reservoirs. Deeper drafts expose additional shoreline to potential bank erosion, sediment entrainment or even slope failures. Deeper drafts also allow access to banks that were previously inundated.

Alternative 2A would have negligible potential for changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Fall Creek, Hills Creek and Lookout Point reservoirs.

Alternative 2A would have negligible potential for changes in sediment trap efficiency relative to NAA at Fall Creek, Hills Creek and Lookout Point reservoirs.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a moderate change in sediment supply with additional fine-grained sediment passing out of Hills Creek dam into the Middle Fork of the Willamette above Lookout Point Reservoir free-flowing reach relative to the NAA. Increased sediment supply is due deeper drafts that have the potential to induce bank erosion and pass fine-grained sediment out of Hills Creek Dam. This fine-grained sediment is expected to pass into Lookout Point Reservoir and deposit.

There is potential for a minor change in sediment supply with additional fine-grained sediment passing into Dexter run-of-river reservoir as compared to the NAA. Increased sediment supply is due to deeper drafts in Lookout Point Reservoir increasing the potential for bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume. These additional fine-grained sediments that enter Dexter Reservoir may settle in the reservoir.

There is negligible potential for change in sediment supply downstream of Dexter Dam.

There is negligible potential for geomorphic change relative to the NAA in the Middle Fork of the Willamette River and Fall Creek free-flowing reaches.

*3.3.2.4.9 Coast Fork of the Willamette River and Row Rivers*

**Storage Projects – Cottage Grove and Dorena**

Alternative 2A would have negligible change in the potential for shoreline exposure, head-of-reservoir sediment mobilization and sediment trap efficiency at Cottage Grove and Dorena reservoirs relative to the NAA.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is negligible potential for changes in sediment supply relative to the NAA in the Coast Fork of the Willamette River and Row River free-flowing reaches. There is negligible potential for geomorphic change relative to the NAA in the Coast Fork of the Willamette River and Row River free-flowing reaches.

*3.3.2.4.10 Evaluation of Near-Term Operations Measure*

**Lower Willamette**

***Run-of-River Reservoir and Free-Flowing Reaches***

There is negligible potential for changes in sediment supply relative to the NAA in the Lower Willamette free-flowing reach. There is negligible potential for geomorphic change relative to the NAA in the Lower Willamette free-flowing reach.

**<u>Middle Willamette</u>**

***Run-of-River Reservoir and Free-Flowing Reaches***

There is negligible potential for changes in sediment supply relative to the NAA in the Middle Willamette free-flowing reach. There is negligible potential for geomorphic change relative to the NAA in the Middle Willamette free-flowing reach.

**<u>Upper Willamette</u>**

***Run-of-River Reservoir and Free-Flowing Reaches***

There is potential for a minor change in sediment supply with additional fine-grained sediment passing into the Upper Willamette free-flowing reach from the Middle Forks of the Willamette and the McKenzie River as compared to the NAA. Increased sediment supply is due to deeper drafts in Fall Creek, Lookout Point, Blue River and Cougar reservoirs that have the potential to pass additional fine-grained sediment downstream. Potential for changes in sediment supply due to changes in reservoir operation would last as long at the Near-Term operations measure is in effect.

There is negligible potential for geomorphic change relative to the NAA in the Upper Willamette free-flowing reach.

**<u>North Santiam</u>**

The near-term operations measure within the North Santiam Basin includes Fall/Winter downstream fish passage through the upper regulating outlets and spring fish passage through strategic use of spillway and turbines at Detroit Dam and spreading spill to reduce total dissolved gas at Big Cliff Dam.

***Storage Projects – Detroit Dam***

The Near-Term operations measure would have negligible change in the potential for head-of-reservoir sediment mobilization and sediment trap efficiency at Detroit Reservoir as compared to the NAA. Although the Near-term Operation at Detroit do not affect reservoir levels, the assumed flow under the "Integrated Temperature and Habitat Flow Regime" measure would impact reservoir levels and would result in a major change in shoreline exposure relative to NAA at Detroit Reservoir due to changes in operational range. Deeper drafts expose additional shoreline to potential bank erosion and sediment entrainment. Deeper drafts also allow access to reservoir banks that were previously inundated. Changes in shoreline exposure would last as long at the Near-Term operations measure is in effect.

***Run-of-River Reservoir and Free-Flowing Reaches***

There is potential for a moderate change in sediment supply with additional fine-grained sediment passing into Big Cliff run-of river reservoir relative to the NAA. Increased sediment supply is due to deeper drafts in Detroit Reservoir increasing the potential for bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume. These additional fine-grained sediments that enter Big Cliff Reservoir may partially settle in the reservoir. Potential for changes in sediment supply due to changes in reservoir operation would last as long at the Near-Term operations measure is in effect.

There is potential for a minor change in fine-grained sediment supply to the North Fork Santiam River downstream of Big Cliff Dam with additional fine-grained sediment passing the dam relative to the NAA. Increased fine-grained sediment supply is due deeper drafts in Detroit Reservoir that have the potential to pass sediment through Detroit Dam and partially through the Big Cliff run-of-river reservoir. Potential for changes in sediment supply due to changes in reservoir operation would last as long at the Near-Term operations measure is in effect.

**South Santiam and Mainstem Santiam**

The near-term operations measure within the South Santiam Subbasin include outplanting of adult Chinook above Green Peter Reservoir, downstream fish passage at Green Peter Dam via the spillway in the spring and fall, and downstream fish passage at Foster via the spillway in the spring and fall.

***Storage Projects – Green Peter and Foster***

The Near-Term operations measure would have major changes in shoreline exposure relative to NAA due to changes in operational range at Green Peter Reservoir. Deeper drafts expose additional shoreline to potential bank erosion, sediment entrainment or even slope failures. Deeper drafts also allow access to banks that were previously inundated. The Near-Term operations measure would have negligible change in shoreline exposure at Foster Reservoir as compared to the NAA. Changes in shoreline exposure would last as long at the Near-Term operations measure is in effect.

The Near-Term operations measure would have the potential for a major change in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Green Peter Reservoir relative to the NAA. Head-of reservoir deposits are typically composed of the coarse-grained sediment supply (sand, gravels and any cobbles that may be in transport) but may also contain some of the coarser silts that can readily settle in the transition from flowing river to quiescent reservoir. There is major potential for stored head-of-reservoir sediment to be re-mobilized and transported further into the reservoir. Future head-of-reservoir deposition would likely deposit further into the reservoir than NAA. The Near-Term operations measure would have negligible change in head-of-reservoir sediment mobilization relative to NAA at Foster Reservoir. Potential changes in head-of-reservoir deposits are due to operations holding the reservoirs lower than NAA during higher inflow where sediment is mobilized and brought into the reservoir from upstream. Potential for Head-of-Reservoir Sediment Mobilization would last as long at the Near-Term operations measure is in effect.

The Near-Term operations measure would have the potential for moderate changes in sediment trap efficiency with reduced trap efficiency relative to NAA at Green Peter Reservoir. The Near-Term operations measure would have minor potential for changes in sediment trap efficiency relative to NAA at Foster Reservoir. Potential changes in reservoir sediment trap efficiency in all cases are due to operations holding the reservoirs lower than NAA, resulting in sufficiently lower reservoir storage volumes, during higher inflow where sediment is mobilized and brought into the reservoir from upstream. Reductions in trap efficiency would mean that a larger fraction of easily suspended, fine-grained sediment may stay in transport and pass these dams. This results in less deposition of these fine-grained sediments in the reservoir and conversely, large quantities of easily suspended, fine-grained sediments passing the reservoir downstream. Potential for changes in sediment trap efficiency would last as long at the Near-Term operations measure is in effect.

***Run-of-River Reservoir and Free-Flowing Reaches***

There is potential for a major change in sediment supply with additional fine-grained sediment passing into Foster Reservoir as compared to the NAA. Increased sediment supply is due to deeper drafts in Green Peter Reservoir. The primary mechanism that is causing the effect determination is that deeper drafts create major potential for bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume. Additionally, there is a moderate decrease in trapping efficiency at Green Peter Reservoir where the dam passes additional inflowing sediment during high flow events relative to the NAA. These additional fine-grained sediments that enter Foster Reservoir may partially settle in the reservoir. Potential for changes in sediment supply due to changes in reservoir operation would last as long at the Near-Term operations measure is in effect.

There is potential for a moderate change in fine-grained sediment supply to the South Fork Santiam River downstream of Foster Dam with additional fine-grained sediment passing the dam as compared to the NAA. Increased fine-grained sediment supply is due deeper drafts in Green Peter Reservoir that have the potential to pass sediment through Green Peter Dam and partially through Foster Reservoir. Potential for changes in sediment supply due to changes in reservoir operation would last as long at the Near-Term operations measure is in effect.

There is potential for a minor change in sediment supply with additional fine-grained sediment passing into the Mainstem Santiam free-flowing reach from the both the North Fork and South Fork Santiam Rivers relative to the NAA. Increased sediment supply is due deeper drafts in Green Peter and Detroit reservoirs that have major potential pass additional fine-grained sediment downstream of the dams. Potential for changes in sediment supply due to changes in reservoir operation would last as long at the Near-Term operations measure is in effect.

<u>Geomorphic Change in Foster Run-of-River Reservoir</u>

Due to the potential for a major change in fine-grained sediment supply into Foster Reservoir from Green Peter draw downs, observable changes in sedimentation rates in Foster Reservoir are likely relative to the NAA. Trapping efficiency for Foster is calculated to be 67% meaning that a portion of the increased fine-grained sediment supply would likely get trapped in the reservoir. This deposition would likely appear as a thicker silt drape within the reservoir and areas along on the banks of Foster reservoir.

**Long Tom River**

There are no local operations proposed under the near-term operations measure within the Long Tom subbasin

***Storage Projects – Fern Ridge***

The Near-Term operations measure would have negligible change from the NAA in the potential for shoreline exposure, head-of-reservoir sediment mobilization and sediment trap efficiency at Fern Ridge Reservoir.

***Run-of-River Reservoir and Free-Flowing Reaches***

There is negligible potential for changes in sediment supply relative to the NAA in the Long Tom River free-flowing reach. There is negligible potential for geomorphic change relative to the NAA in the Long Tom River free-flowing reach.

**McKenzie and Blue Rivers**

The near-term operations measure within the McKenzie Subbasin includes spring and fall drawdown for fish passage at Cougar Reservoir to a target elevation of 1505 feet.

***Storage Projects – Cougar and Blue River***

The Near-Term operations measure would have major changes in shoreline exposure relative to NAA due to changes in operational range at Cougar and Blue River reservoirs. Deeper drafts expose additional shoreline to potential bank erosion, sediment entrainment or even slope failures. Deeper drafts also allow access to banks that were previously inundated. Potential for changes in shoreline exposure would last as long at the Near-Term operations measure is in effect.

The Near-Term operations measure would have the potential for minor changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Cougar Reservoir. There is minor potential for stored head-of-reservoir sediment to be re-mobilized and transported further into the reservoir. Future head-of-reservoir deposition would likely deposit further into the reservoir than NAA. Potential changes in head-of-reservoir deposits are due to operations holding the reservoirs lower than NAA during higher inflow where sediment is mobilized and brought into the reservoir from upstream. The Near-Term operations measure would have the potential for negligible changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Blue River Reservoir.

Head-of reservoir deposits are typically composed of the coarse-grained sediment supply (sand, gravels and any cobbles that may be in transport) but may also contain some of the coarser silts that can readily settle in the transition from flowing river to quiescent reservoir. Potential for Head-of-Reservoir Sediment Mobilization would last as long at the Near-Term operations measure is in effect.

The Near-Term operations measure would have the potential for minor changes in sediment trap efficiency with reduced trap efficiency relative to NAA at Cougar Reservoir. The Near-Term operations measure would have the potential for negligible changes in sediment trap efficiency with reduced trap efficiency relative to NAA at Blue River Reservoir. Potential changes in reservoir sediment trap efficiency in all cases are due to operations holding the reservoirs lower than NAA, resulting in sufficiently lower reservoir storage volumes, during higher inflow where sediment is mobilized and brought into the reservoir from upstream. Reductions in trap efficiency would mean that a larger fraction of easily suspended, fine-grained sediment may stay in transport and pass these dams. This results in less deposition of these fine-grained sediments in the reservoir and conversely, large quantities of easily suspended, fine-grained sediments passing the reservoir downstream. Potential for changes in sediment trap efficiency would last as long at the Near-Term operations measure is in effect.

***Run-of-River Reservoir and Free-Flowing Reaches***

There is potential for a moderate change in fine-grained sediment supply to the McKenzie River downstream of Cougar Dam, and the Blue River downstream of Blue River Dam, with additional fine-grained sediment passing the dam as compared to the NAA. Increased fine-grained sediment supply is due deeper drafts in Cougar Reservoir increasing the potential for bank erosion and sloughing generating sediment in the reservoir that may pass the dam due to a concurrent reduction in reservoir storage volume. Potential for changes in sediment supply due to changes in reservoir operation would last as long at the Near-Term operations measure is in effect.

**Middle Fork of the Willamette River and Fall Creek**

The near-term operations measure within the Middle Fork Willamette Subbasin includes use of the regulating outlet for downstream fish passage at Hills Creek, deep drafts for fish passage at Lookout Point in winter, use of the spillway for fish passage at Lookout Point in the spring, use of the Lookout Point regulating outlets for temperature management in the summer and fall, and deep drafts for fish passage in the fall at Fall Creek. For the operations at Lookout Point, storage at Hills Creek would be used for refilling Lookout Point in early March.

***Storage Projects – Fall Creek, Lookout Point and Hills Creek***

The Near-Term operations measure would have the potential for major changes in bank exposure relative to NAA due to changes in operational range at Lookout Point and Hills Creek reservoirs. The Near-Term operations measure would have the potential for major changes in bank exposure relative to NAA due to changes in operations that hold the pool lower for longer periods of time at Fall Creek Reservoir. Potential for changes in shoreline exposure would last as long at the Near-Term operations measure is in effect.

The Near-Term operations measure would have the potential for major changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Fall Creek and Lookout Point reservoirs. At Fall Creek there is major potential for transient and longer-term head of reservoir sediment to deposit lower in the reservoir due to operations that hold the reservoir lower during high inflow periods. At Lookout Point there is major potential for stored head-of-reservoir sediment to be re-mobilized and transported further into the reservoir. Future head-of-reservoir deposition would likely deposit further into the reservoir than NAA. Potential changes in head-of-reservoir deposits are due to operations holding the reservoirs lower than NAA during higher inflow where sediment is mobilized and brought into the reservoir from upstream.

The Near-Term operations measure would have the potential for minor changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Hills Creek Reservoir. There is minor potential for stored head-of-reservoir sediment to be re-mobilized and transported further into the reservoir. Future head-of-reservoir deposition would likely deposit further into the reservoir than NAA. Potential changes in head-of-reservoir deposits are due to operations holding the reservoirs lower than NAA during higher inflow where sediment is mobilized and brought into the reservoir from upstream

Head-of reservoir deposits are typically composed of the coarse-grained sediment supply (sand, gravels and any cobbles that may be in transport) but may also contain some of the coarser silts that can readily settle in the transition from flowing river to quiescent reservoir. Potential changes in Head-of-Reservoir Sediment Mobilization would last as long at the Near-Term operations measure is in effect.

The Near-Term operations measure would have the potential for major changes in sediment trap efficiency with reduced trap efficiency relative to NAA at Fall Creek Reservoir. The Near-Term operations measure would have the potential for moderate changes in sediment trap efficiency with reduced trap efficiency relative to NAA at Lookout Point Reservoir. The Near-Term operations measure would have negligible changes in sediment trap efficiency relative to NAA at Hills Creek Reservoir. Potential changes in reservoir sediment trap efficiency are due to operations holding the reservoirs lower than NAA, resulting in sufficiently lower reservoir storage volumes, during higher inflow where sediment is mobilized and brought into the reservoir from upstream. Reductions in trap efficiency would mean that a larger fraction of easily suspended, fine-grained sediment may stay in transport and pass these dams. This results in less deposition of these fine-grained sediments in the reservoir and conversely, large quantities of easily suspended, fine-grained sediments passing the reservoir downstream. Potential for changes in sediment trap efficiency would last as long at the Near-Term operations measure is in effect.

#### *Run-of-River Reservoir and Free-Flowing Reaches*

There is moderate potential for changes in sediment supply relative to the NAA in the Middle Fork of the Willamette above Lookout Point Reservoir free-flowing reach. This potential increase in fine-grained sediment supply is due to deeper drafts in Hills Creek Reservoir that create major potential for bank erosion and sloughing, generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume. Potential for changes in sediment supply due to changes in reservoir operation would last as long at the Near-Term operations measure is in effect.

There is potential for a major change in sediment supply into Dexter Reservoir with additional fine-grained sediment passing out of Lookout Point Dam run-of-river reservoir as compared to the NAA. Increased sediment supply is due to deeper drafts in Lookout Point Reservoir. The primary mechanism that is causing the effect determination is deeper drafts in Lookout Point Reservoir that create major potential for bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume. These additional fine-grained sediments that enter Dexter Reservoir may partially settle in the reservoir. Potential for changes in sediment supply due to changes in reservoir operation would last as long at the Near-Term operations measure is in effect.

There is potential for a moderate change in sediment supply with additional fine-grained sediment passing into the Middle Fork of the Willamette below Dexter Dam free-flowing reach and from Fall Creek relative to the NAA. Increased sediment supply is due deeper drafts in Lookout Point Reservoir that have potential pass additional fine-grained sediment downstream and partially through Dexter Reservoir as well as deeper draft in Fall Creek Reservoir that increase fine grained sediment supply to Fall Creek. Potential for changes in sediment supply due to changes in reservoir operation would last as long at the Near-Term operations measure is in effect.

There is major potential for changes in sediment supply relative to the NAA in the Fall Creek free-flowing reach downstream of Fall Creek Dam. This potential increase in fine-grained sediment supply is due to deeper drafts in Fall Creek Reservoir during higher flows that reduce trapping efficiency. Potential for changes in sediment supply due to changes in reservoir operation would last as long at the Near-Term operations measure is in effect.

Geomorphic Change in Dexter Run-of-River Reservoir

Due to the potential for a major change in fine-grained sediment supply into Dexter Reservoir from Lookout Point draw downs, observable changes in sedimentation rates in Dexter Reservoir are likely as compared to the NAA. Trapping efficiency for Dexter is calculated to be 51% meaning that a portion of the increased fine-grained sediment supply would likely get trapped in the reservoir. This deposition would likely appear as a thicker silt drape within the reservoir and areas along on the banks of Dexter reservoir.

**Coast Fork of the Willamette River and Row Rivers**

There are no local operations proposed under the near-term operations measure within the Coast Fork subbasin.

***Storage Projects – Cottage Grove and Dorena***

The Near-Term operations measure would have negligible change from the NAA in the potential for shoreline exposure, head-of-reservoir sediment mobilization and sediment trap efficiency at Cottage Grove and Dorena reservoirs.

***Run-of-River Reservoir and Free-Flowing Reaches***

There is negligible potential for changes in sediment supply relative to the NAA in the Coast Fork of the Willamette River and Row River free-flowing reaches. There is negligible potential for geomorphic change relative to the NAA in the Coast Fork of the Willamette River and Row River free-flowing reaches.

*3.3.2.4.11 Climate Change*

Alternative 2A would have negligible potential for change in sediment conditions due to climate change relative to the NAA in all reservoirs and reaches except Green Peter and Foster dams. Deeper drafts at Green Peter Dam have to potential to pass increased climate change driven fine grained sediment into Foster Reservoir resulting in increased deposition in Foster Reservoir and increased fine-grained sediment supply to the South Santiam downstream of Foster Dam.

*3.3.2.4.12 Summary of Effects of Alternative 2A*

Table 3.3-3 shows the summary of effects under Alternative 2A.

**Table 3.3-3. Summary of effects for River Mechanics and Geomorphology under Alternative 2A as Compared to the NAA**

| Subbasin | Alternative 2A |
|---|---|
| **General** | Effects to river mechanics and geomorphology metrics are none/negligible except those stated below. |
| **Santiam Subbasin** | Detroit and Green Peter storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts. Additionally, Green Peter would have moderate effects with decreases in sediment trap efficiency and major changes in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir.<br><br>Downstream of the storage projects, there is potential for a moderate effects with an increase in fine grained sediment supply into the Big Cliff re-regulation project which in turn may pass a minor |

| Subbasin | Alternative 2A |
|---|---|
| | increase in fine grained sediment downstream into the North Santiam free-flowing reach. There is potential for a major effect with an increase in fine grained sediment supply to Foster reservoir from Green Peter which in partially settle in the Foster pool and in turn may pass a moderate increase in fine grained sediment supply downstream into the South Santiam.<br><br>Gravel augmentation below dams (#384) measure would have major effects to geomorphology downstream of Big Cliff and Foster dams and would modify the geomorphology of the North Fork Santiam and South Fork Santiam respectively. |
| **Long Tom Subbasin** | Negligible effects |
| **McKenzie Subbasin** | Cougar and Blue River storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts.<br><br>Downstream of the storage projects, there is potential for a minor effects with an increase in fine grained sediment supply into the South Fork McKenzie and a moderate increase of fine-grained sediment supply into Blue River.<br><br>Gravel augmentation below dams (#384) measure would have major effects to geomorphology downstream of the South Fork McKenzie and Blue River dams and would modify the geomorphology of the South Fork McKenzie and Blue River respectively. |
| **Middle Fork of the Willamette Subbasin** | Hills Creek and Lookout Point storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts.<br><br>Downstream of the storage projects, there is potential for a moderate effects with an increase in fine grained sediment supply below Hills Creek and a minor increase in fine-grained sediment supply below Lookout Point entering Dexter Reservoir. |
| **Coast Fork of the Willamette Subbasin** | Negligible effects |
| **Mainstem Willamette River** | Negligible effects |

### ***3.3.2.5 Alternative 2B***

See Section 2.4.5 for a complete description of Alternative 2B. Alternative 2B effects are relative to the NAA and are summarized by impact type in this section. See Appendix C, Chapter 2 for metric calculations and supporting figures.

Alternative 2B effects are the same as Alternative 2A for all geographical subregions and metrics with the exception of the Middle Willamette, Upper Willamette and the McKenzie and Blue River subregion. See section 3.3.2.4, Alternative 2A, for description of effects other than those described below.

#### *3.3.2.5.1 Middle Willamette*

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a minor change in sediment supply with additional fine-grained sediment passing into the Middle Willamette free-flowing reach from the Upper Willamette as compared to the NAA. Increased sediment supply is due deeper drafts in Cougar and Blue River reservoirs Reservoir that would have the potential pass additional fine-grained sediment downstream.

There is negligible potential for geomorphic change relative to the NAA in the Middle Willamette free-flowing reach.

#### *3.3.2.5.2 Upper Willamette*

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a moderate change in sediment supply with additional fine-grained sediment passing into the Upper Willamette free-flowing reach from the McKenzie River relative to the NAA. Increased sediment supply is due deeper drafts in Cougar and Blue River reservoirs that would have the potential pass additional fine-grained sediment downstream.

There is negligible potential for geomorphic change relative to the NAA in the Upper Willamette free-flowing reach.

#### *3.3.2.5.3 McKenzie and Blue Rivers*

**Storage Projects – Cougar and Blue River**

Alternative 2B would have major changes in shoreline exposure relative to NAA due to changes in operational range at Cougar and Blue River reservoirs. Deeper drafts expose additional shoreline to potential bank erosion, sediment entrainment or even slope failures. Deeper drafts also allow access to banks that were previously inundated.

Alternative 2B would have the potential for major changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Cougar Reservoir. There is major potential for stored head-of-reservoir sediment to be re-mobilized and transported further into the reservoir. Future head-of-reservoir deposition would likely deposit further into the reservoir than NAA. Potential changes in head-of-reservoir deposits are due to operations holding the reservoirs lower than NAA during higher inflow where sediment is mobilized and brought into the reservoir from upstream. Alternative 2B would have negligible potential for changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Blue River Reservoir.

Head-of reservoir deposits are typically composed of the coarse-grained sediment supply (sand, gravels and any cobbles that may be in transport) but may also contain some of the coarser silts that can readily settle in the transition from flowing river to quiescent reservoir.

Alternative 2B would have the potential for major changes in sediment trap efficiency with reduced trap efficiency relative to NAA at Cougar Reservoir. Potential changes in reservoir sediment trap efficiency are due to operations holding the reservoirs lower than NAA, resulting in sufficiently lower reservoir storage volumes, during higher inflow where sediment is mobilized and brought into the reservoir from upstream. Reductions in trap efficiency would mean that a larger fraction of easily suspended, fine-grained sediment may stay in transport and pass these dams. This results in less deposition of these fine-grained sediments in the reservoir and conversely, large quantities of easily suspended, fine-grained sediments passing the reservoir downstream. Alternative 2B would have negligible potential for changes in sediment trap efficiency relative to NAA at Blue River Reservoir.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is a major change in coarse-grained bed material sediment supply to the McKenzie River free-flowing reach below Cougar Dam due to direct placement of bed material sized sediment through gravel augmentation below dams (#384) relative to the NAA. Additionally, there is potential for a major change in fine-grained sediment supply to the McKenzie River downstream of Cougar Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply is due deeper draft in Cougar Reservoir that cause a major decrease in trapping efficiency and a major increase in the potential for bank erosion and sloughing generating sediment in the reservoir that may pass the dam due to a concurrent reduction in reservoir storage volume.

There is a major change in coarse-grained bed material sediment supply to the Blue River free-flowing reach below Blue River Dam due to direct placement of bed material sized sediment through gravel augmentation below dams (#384) as compared to the NAA. Additionally, there is potential for a moderate change in fine-grained sediment supply to the Blue River downstream of Blue River Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply is due deeper draft in Blue River Reservoir that cause a moderate increase in the potential for bank erosion and sloughing generating sediment in the reservoir that may pass the dam due to a concurrent reduction in reservoir storage volume.

***Geomorphic Change Below Cougar Dam***

There is major potential for geomorphic change in the South Fork McKenzie downstream of Cougar Dam due to the gravel augmentation below dams (#384) measure and fine-grained passing Cougar Dam relative to the NAA. Sediment augmentation in the South Fork McKenzie River below Cougar Dam is proposed to maintain and enhance the existing high quality and quantity of habitat for Spring Chinook and Winter Steelhead developed in the reach since 2018. Gravel augmentation below dams (#384) would annually place an appropriate quantity of specifically sized and graded sediments into the river prior to seasonal high flows and spawning. The placed material would be distributed by the river during high flows and integrate itself into the existing anastomosing mosaic downstream established during prior river restoration activities. Sediments are expected to move slowly through the restoration reach and potentially store for longer periods of time as normative river process occur.

Because the armored plane bed condition of the river has already been addressed by restoration actions, the goal of the augmentation is to supply required sediment into an existing process-based floodplain reengagement action. The gradation classes of the augmentation would necessarily be more varied and smaller than a typical confined valley spawning gravel augmentation project.

River condition monitoring, along with gravel augmentation below dams (#384) that may change the quantity, size or injection location of sediment augmentation, would identify and respond to river changes to improve targeted habitat maintenance goals and limit adverse effects.

Due to the potential for a major change in fine-grained sediment supply from Cougar Dam draw downs, observable turbidity and deposition of fines is expected in the South Fork McKenzie and potentially main stem McKenzie downstream of the South Fork confluence.

***Geomorphic Change Below Blue River Dam***

There is major potential for geomorphic change in the Blue River and potentially in the mainstem McKenzie downstream of Blue River Dam due to the gravel augmentation below dams (#384) measure relative to the NAA. Geomorphic effects of gravel augmentation below Blue River Dam as the same as Alternative 1. See Section 3.3.2.3.7 for description of effects.

#### *3.3.2.5.4 Evaluation of Near-Term Operations Measure*

See Alternative 2A, Section 3.3.3.3, for description of effects due to the Near-Term Operations Measure.

#### *3.3.2.5.5 Climate Change*

Alternative 2B would have negligible potential for change in sediment conditions due to climate change relative to the NAA in all reservoirs and reaches except Green Peter, Foster and Cougar dams and the McKenzie downstream of Cougar Dam. Deeper drafts at Green Peter Dam have to potential to pass increased climate change driven fine grained sediment into Foster Reservoir resulting in increased deposition in Foster Reservoir and increased fine-grained sediment supply to the South Santiam downstream of Foster Dam. Deeper drafts at Cougar Dam have to potential to pass increased climate change driven fine grained sediment in the South Fork McKenzie downstream of the dam.

#### *3.3.2.5.6 Summary of Effects of Alternative 2B*

Table 3.3-4 shows the summary of effects under Alternative 2B.

**Table 3.3-4. Summary of effects for River Mechanics and Geomorphology under Alternative 2B Compared to the NAA**

| Subbasin | Alternative 2B |
|---|---|
| **General** | Effects to river mechanics and geomorphology metrics are none/negligible except those stated below. |
| **Santiam Subbasin** | Detroit and Green Peter storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts. Additionally, Green Peter would have moderate effects with decreases in sediment trap efficiency and major changes in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir.<br><br>Downstream of the storage projects, there is potential for a moderate effects with an increase in fine grained sediment supply into the Big Cliff re-regulation project which in turn may pass a minor increase in fine grained sediment downstream into the North Santiam free-flowing reach. There is potential for a major effects with an increase in fine grained sediment supply to Foster reservoir from Green Peter which in partially settle in the Foster pool and in turn may pass a moderate increase in fine grained sediment supply downstream into the South Santiam.<br><br>Gravel augmentation below dams (#384) measure would have major effects to geomorphology downstream of Big Cliff and Foster dams and would modify the geomorphology of the North Fork Santiam and South Fork Santiam respectively. |
| **Long Tom Subbasin** | Negligible effects |
| **McKenzie Subbasin** | Cougar and Blue River storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts. Additionally, the Cougar storage project would have major effects with decreased sediment trapping efficiency and changes in head of reservoir sediment mobilization with sediment deposition deeper in the reservoir. |

| Subbasin | Alternative 2B |
|---|---|
| | Downstream of the storage projects, there is potential for a major effects with an increase in fine grained sediment supply into the South Fork McKenzie and a moderate effects with an increase of fine-grained sediment supply into Blue River from the reservoirs.<br><br>Gravel augmentation below dams (#384) measure would have major effects to geomorphology downstream of the South Fork McKenzie and Blue River dams and would modify the geomorphology of the South Fork McKenzie and Blue River respectively. |
| **Middle Fork of the Willamette Subbasin** | Hills Creek and Lookout Point storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts.<br><br>Downstream of the storage projects, there is potential for a moderate effect with an increase in fine grained sediment supply below Hills Creek and a minor increase in fine-grained sediment supply below Lookout Point entering Dexter Reservoir. |
| **Coast Fork of the Willamette Subbasin** | Negligible effects |
| **Mainstem Willamette River** | There is potential for a moderate effect with an increase in fine grained sediment supply entering the mainstem Willamette from the McKenzie River due to changes in operations at Cougar Dam. |

#### *3.3.2.6 Alternative 3A*

See Section 2.4.6 for a complete description of Alternative 3A. Alternative 3A effects are relative to the NAA and are summarized by impact type in this section. See Appendix C, Chapter 2 for metric calculations and supporting figures.

##### *3.3.2.6.1 Lower Willamette*

**Run-of-River Reservoir and Free-Flowing Reaches**

There is negligible potential for changes in sediment supply relative to the NAA in the Lower Willamette free-flowing reach. There is negligible potential for geomorphic change relative to the NAA in the Lower Willamette free-flowing reach.

*3.3.2.6.2 Middle Willamette*

**Run-of-River Reservoir and Free-Flowing Reaches**

There is negligible potential for changes in sediment supply relative to the NAA in the Middle Willamette free-flowing reach. There is negligible potential for geomorphic change relative to the NAA in the Middle Willamette free-flowing reach.

*3.3.2.6.3 Upper Willamette*

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a minor change in sediment supply with additional fine-grained sediment passing into the Upper Willamette free-flowing reach from the Coast and Middle Forks of the Willamette and the McKenzie River as compared to the NAA. Increased sediment supply is due deeper drafts in Cottage Grove, Dorena, Lookout Point, Blue River and Cougar reservoirs that have the potential pass additional fine-grained sediment downstream.

There is negligible potential for geomorphic change relative to the NAA in the Upper Willamette free-flowing reach.

*3.3.2.6.4 North Santiam*

**Storage Projects – Detroit Dam**

Alternative 3A would have the potential for major changes in shoreline exposure relative to NAA due to changes in operational range at Detroit Reservoir. Deeper drafts expose additional shoreline to potential bank erosion, sediment entrainment or even slope failures. Deeper drafts also allow access to banks that were previously inundated.

Alternative 3A would have the potential for major changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Detroit Reservoir. There is major potential for stored head-of-reservoir sediment to be re-mobilized and transported further into the reservoirs. Future head-of-reservoir deposition would likely deposit further into the reservoir than NAA. Potential changes in head-of-reservoir deposits are due to operations holding the reservoirs lower than NAA during higher inflow where sediment is mobilized and brought into the reservoir from upstream.

Alternative 3A would have the potential for major changes in sediment trap efficiency with reduced trap efficiency relative to NAA at Detroit Reservoir. Potential changes in reservoir sediment trap efficiency are due to operations holding the reservoir lower than NAA, resulting in sufficiently lower reservoir storage volumes, during higher inflow where sediment is mobilized and brought into the reservoir from upstream. Reductions in trap efficiency would mean that a larger fraction of easily suspended, fine-grained sediment may stay in transport and pass these dams. This results in less deposition of these fine-grained sediments in the reservoir and conversely, large quantities of easily suspended, fine-grained sediments passing the reservoir downstream.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a major change in sediment supply with additional fine-grained sediment passing into Big Cliff run-of-river reservoir as compared to the NAA. Increased sediment supply is due to deeper drafts in Detroit Reservoir. The primary mechanism that is causing the effect determination is a major decrease in trapping efficiency at Detroit Reservoir where the dam passes additional inflowing sediment during high flow events. Additionally, deeper drafts moderately increase the potential for bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume. These additional fine-grained sediments that enter Big Cliff Reservoir may partially settle in the reservoir.

There is a major change in coarse-grained bed material sediment supply to the North Santiam free-flowing reach due to direct placement of bed material sized sediment through gravel augmentation below dams (#384) relative to the NAA. Additionally, there is potential for a moderate change in fine-grained sediment supply to the North Fork Santiam River downstream of Big Cliff Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply is due deeper drafts in Detroit Reservoir that have the potential to pass sediment through Detroit Dam and partially through the Big Cliff run-of-river reservoir.

***Geomorphic Change in Big Cliff Run-of-River Reservoir***

Due to the potential for a major change in fine-grained sediment supply into Big Cliff Reservoir from Detroit draw downs, observable changes in sedimentation rates in Big Cliff Reservoir are likely relative to the NAA. Trapping efficiency for Big Cliff is calculated to be 96% meaning that a large portion of the increased fine-grained sediment supply would get trapped in the reservoir. This deposition would likely appear as a thicker silt drape within the reservoir and areas along on the banks of Big Cliff reservoir.

***Geomorphic Change Below Big Cliff***

There is major potential for geomorphic change in the North Santiam downstream of Big Cliff Dam due to the gravel augmentation below dams (#384) measure relative to the NAA. Geomorphic effects below Big Cliff Dam as the same as Alternative 1. See the Section 3.3.2.3.4 for description of effects.

*3.3.2.6.5 South Santiam and Mainstem Santiam*

**Storage Projects – Green Peter and Foster**

Alternative 3A would have major changes in shoreline exposure relative to NAA due to changes in operational range at Green Peter Reservoir. Deeper drafts expose additional shoreline to potential bank erosion, sediment entrainment or even slope failures. Deeper drafts also allow access to banks that were previously inundated. Alternative 3A would have negligible change in shoreline exposure at Foster Reservoir.

Alternative 3A would have the potential for a major change in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Green Peter Reservoir. There is major potential for stored head-of-reservoir sediment to be re-mobilized and transported further into the reservoir. Future head-of-reservoir deposition would likely deposit further into the reservoir than NAA. Potential changes in head-of-reservoir deposits are due to operations holding the reservoirs lower than NAA during higher inflow where sediment is mobilized and brought into the reservoir from upstream.

Alternative 3A would have the potential for minor change in head-of-reservoir sediment mobilization relative to NAA in Foster Reservoir. This is due to changes in operations at Green Peter Reservoir upstream. Peak flows entering Foster Reservoir when the pool is drawn down are decreased, however there is an increase in fall flows when the reservoir is full. There is minor potential for future head-of-reservoir deposition to occur higher in the reservoir relative to NAA.

Head-of reservoir deposits are typically composed of the coarse-grained sediment supply (sand, gravels and any cobbles that may be in transport) but may also contain some of the coarser silts that can readily settle in the transition from flowing river to quiescent reservoir.

Alternative 3A would have the potential for moderate changes in sediment trap efficiency with reduced trap efficiency relative to NAA at Green Peter Reservoir. Alternative 3B would have negligible potential for changes in sediment trap efficiency relative to NAA at Foster Reservoir. Potential changes in reservoir sediment trap efficiency in all cases are due to operations holding the reservoirs lower than NAA, resulting in sufficiently lower reservoir storage volumes, during higher inflow where sediment is mobilized and brought into the reservoir from upstream. Reductions in trap efficiency would mean that a larger fraction of easily suspended, fine-grained sediment may stay in transport and pass these dams. This results in less deposition of these fine-grained sediments in the reservoir and conversely, large quantities of easily suspended, fine-grained sediments passing the reservoir downstream.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a major change in sediment supply with additional fine-grained sediment passing into Foster Reservoir relative to the NAA. Increased sediment supply is due to deeper drafts in Green Peter Reservoir. The primary mechanism that is causing the effect determination is deeper drafts create major potential for bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume. Additionally, there is a moderate decrease in trapping efficiency at Green Peter Reservoir where the dam passes additional inflowing sediment during high flow events. These additional fine-grained sediments that enter Foster Reservoir may partially settle in the reservoir.

There is a major change in coarse-grained bed material sediment supply to the South Santiam free-flowing reach due to direct placement of bed material sized sediment through gravel augmentation below dams (#384) as compared to the NAA. Additionally, there is potential for a moderate change in fine-grained sediment supply to the South Fork Santiam River downstream of Foster Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply is due deeper drafts in Green Peter Reservoir that have the potential to pass sediment through Green Peter Dam and partially through Foster Reservoir.

There is potential for a minor change in sediment supply with additional fine-grained sediment passing into the Mainstem Santiam free-flowing reach from the both the North Fork and South Fork Santiam Rivers. Increased sediment supply is due deeper drafts in Green Peter and Detroit reservoirs that have major potential pass additional fine-grained sediment downstream of the dams.

***Geomorphic Change in Foster Run-of-River Reservoir***

Due to the potential for a major change in fine-grained sediment supply into Foster Reservoir from Green Peter draw downs, observable changes in sedimentation rates in Foster Reservoir are likely as compared to the NAA. Trapping efficiency for Foster is calculated to be 67%, meaning that a portion of the increased fine-grained sediment supply would likely get trapped in the reservoir. This deposition would likely appear as a thicker silt drape within the reservoir and areas along on the banks of Foster Reservoir.

***Geomorphic Change Below Foster Dam***

There is major potential for geomorphic change in the South Santiam downstream of Foster Dam due to the gravel augmentation below dams (#384) measure as compared to the NAA. Geomorphic effects below Foster Dam as the same as Alternative 1. See Section 3.3.2.3.5 for description of effects.

*3.3.2.6.6 Long Tom River*

**Storage Projects – Fern Ridge**

Alternative 3A would have negligible change from the NAA in the potential for shoreline exposure, head-of-reservoir sediment mobilization and sediment trap efficiency at Fern Ridge Reservoir.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is negligible potential for changes in sediment supply relative to the NAA in the Long Tom River free-flowing reach. There is negligible potential for geomorphic change relative to the NAA in the Long Tom River free-flowing reach.

### *3.3.2.6.7 McKenzie and Blue Rivers*

**Storage Projects – Cougar and Blue River**

Alternative 3A would have the potential for major changes in shoreline exposure relative to NAA due to changes in operational range at Cougar and Blue River reservoirs. Deeper drafts expose additional shoreline to potential bank erosion, sediment entrainment or even slope failures. Deeper drafts also allow access to banks that were previously inundated.

Alternative 3A would have the potential for major changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Cougar Reservoir. There is major potential for stored head-of-reservoir sediment to be re-mobilized and transported further into the reservoir. Future head-of-reservoir deposition would likely deposit further into the reservoir than NAA. Potential changes in head-of-reservoir deposits are due to operations holding the reservoirs lower than NAA during higher inflow where sediment is mobilized and brought into the reservoir from upstream.

Alternative 3A would have the potential for minor changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Blue River Reservoir. There is minor potential for stored head-of-reservoir sediment to be re-mobilized and transported further into the reservoir. Future head-of-reservoir deposition would likely deposit further into the reservoir than NAA. Potential changes in head-of-reservoir deposits are due to operations holding the reservoirs lower than NAA during higher inflow where sediment is mobilized and brought into the reservoir from upstream

Head-of reservoir deposits are typically composed of the coarse-grained sediment supply (sand, gravels and any cobbles that may be in transport) but may also contain some of the coarser silts that can readily settle in the transition from flowing river to quiescent reservoir.

Alternative 3A would have the potential for moderate changes in sediment trap efficiency with reduced trap efficiency relative to NAA at Cougar Reservoir. Alternative 3A would have the potential for minor changes in sediment trap efficiency with reduced trap efficiency relative to NAA at Blue River Reservoir. Potential changes in reservoir sediment trap efficiency in all cases are due to operations holding the reservoirs lower than NAA, resulting in sufficiently lower reservoir storage volumes, during higher inflow where sediment is mobilized and brought into the reservoir from upstream. Reductions in trap efficiency would mean that a larger fraction of easily suspended, fine-grained sediment may stay in transport and pass these dams. This results in less deposition of these fine-grained sediments in the reservoir and conversely, large quantities of easily suspended, fine-grained sediments passing the reservoir downstream.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is a major change in coarse-grained bed material sediment supply to the McKenzie River free-flowing reach below Cougar Dam due to direct placement of bed material sized sediment through gravel augmentation below dams (#384) as compared to the NAA. Additionally, there is potential for a moderate change in fine-grained sediment supply to the McKenzie River downstream of Cougar Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply is due deeper draft in Cougar Reservoir that cause a moderate decrease in trapping efficiency and a minor increase in the potential for bank erosion and sloughing generating sediment in the reservoir that may pass the dam due to a concurrent reduction in reservoir storage volume.

There is a major change in coarse-grained bed material sediment supply to the Blue River free-flowing reach below Blue River Dam due to direct placement of bed material sized sediment through gravel augmentation below dams (#384) relative to the NAA. Additionally, there is potential for a moderate change in fine-grained sediment supply to the Blue River downstream of Blue River Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply is due deeper draft in Blue River Reservoir that cause a minor decrease in trapping efficiency and a moderate increase in the potential for bank erosion and sloughing generating sediment in the reservoir that may pass the dam due to a concurrent reduction in reservoir storage volume.

***Geomorphic Change Below Cougar Dam***

There is major potential for geomorphic change in the South Fork McKenzie downstream of Cougar Dam due to the gravel augmentation below dams (#384) measure as compared to the NAA. Geomorphic effects of gravel augmentation below Cougar Dam as the same as Alternative 1. See Section 3.3.2.3.7 for description of effects.

***Geomorphic Change Below Blue River Dam***

There is major potential for geomorphic change in the Blue River and potentially in the mainstem McKenzie downstream of Blue River Dam due to the gravel augmentation below dams (#384) measure relative to the NAA. Geomorphic effects of gravel augmentation below Blue River Dam as the same as Alternative 1. See Section 3.3.2.3.7 for description of effects.

*3.3.2.6.8 Middle Fork of the Willamette River and Fall Creek*

**Storage Projects – Fall Creek, Lookout Point and Hills Creek**

Alternative 3A would have the potential for major changes in bank exposure relative to NAA due to changes in operational range at Lookout Point Reservoir. The proposed operational range change at Hills Creek Reservoir is to lower the minimum pool by 1 foot which is well withing the typical daily fluctuation and wave height condition. The calculated shoreline exposure metric shows a potential for minor change in Hills Creek shoreline exposure. A minor change in shoreline exposure at Hills Creek with the reservoir being drawn deeper more frequently is an appropriate effect given the small minimum pool change. Alternative 3A would have negligible change in shoreline exposure at Fall Creek Reservoir.

Alternative 3A would have the potential for major changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Lookout Point Reservoir. There is major potential for stored head-of-reservoir sediment to be re-mobilized and transported further into the reservoir. Future head-of-reservoir deposition would likely deposit further into the reservoir than NAA. Potential changes in head-of-reservoir deposits are due to operations holding the reservoirs lower than NAA during higher inflow where sediment is mobilized and brought into the reservoir from upstream.

Alternative 3A would have the potential for minor changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Hills Creek Reservoir. There is minor potential for stored head-of-reservoir sediment to be re-mobilized and transported further into the reservoir. Future head-of-reservoir deposition would likely deposit further into the reservoir than NAA. Potential changes in head-of-reservoir deposits are due to operations holding the reservoirs lower than NAA during higher inflow where sediment is mobilized and brought into the reservoir from upstream

Alternative 3A would have negligible potential for changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Falls Creek Reservoir.

Head-of reservoir deposits are typically composed of the coarse-grained sediment supply (sand, gravels and any cobbles that may be in transport) but may also contain some of the coarser silts that can readily settle in the transition from flowing river to quiescent reservoir.

Alternative 3A would have the potential for major changes in sediment trap efficiency with reduced trap efficiency relative to NAA at Lookout Point Reservoir. Alternative 3A would have negligible potential for changes in sediment trap efficiency relative to NAA Fall Creek and Hills Creek reservoirs. Potential changes in reservoir sediment trap efficiency are due to operations holding the reservoirs lower than NAA, resulting in sufficiently lower reservoir storage volumes, during higher inflow where sediment is mobilized and brought into the reservoir from upstream. Reductions in trap efficiency would mean that a larger fraction of easily suspended, fine-grained sediment may stay in transport and pass these dams. This results in less deposition of these fine-grained sediments in the reservoir and conversely, large quantities of easily suspended, fine-grained sediments passing the reservoir downstream.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is negligible potential for changes in sediment supply relative to the NAA in the Middle Fork of the Willamette above Lookout Point Reservoir free-flowing reach.

There is potential for a major change in sediment supply into Dexter Reservoir with additional fine-grained sediment passing out of Lookout Point Dam run-of-river reservoir as compared to the NAA. Increased sediment supply is due to deeper drafts in Lookout Point Reservoir decreasing trap efficiency and increasing the potential for bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume. There is major potential for bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume. Additionally, there is a major decrease in trapping efficiency at Lookout Point Reservoir where the dam passes additional inflowing sediment during high flow events. These additional fine-grained sediments that enter Dexter Reservoir may partially settle in the reservoir.

There is potential for a moderate change in sediment supply with additional fine-grained sediment passing into the Middle Fork of the Willamette below Dexter Dam free-flowing reach. Increased sediment supply is due deeper drafts in Lookout Point Reservoir that have potential pass additional fine-grained sediment downstream and partially through Dexter Reservoir.

There is negligible potential for changes in sediment supply relative to the NAA in the Fall Creek free-flowing reach downstream of Fall Creek Dam.

***Geomorphic Change in Dexter Run-of-River Reservoir***

Due to the potential for a major change in fine-grained sediment supply into Dexter Reservoir from Lookout Point drafts, observable changes in sedimentation rates in Dexter Reservoir are likely. Trapping efficiency for Dexter is calculated to be 51%, meaning that a portion of the increased fine-grained sediment supply would likely get trapped in the reservoir. This deposition would likely appear as a thicker silt drape within the reservoir and areas along on the banks of Dexter Reservoir.

##### *3.3.2.6.9 Coast Fork of the Willamette River and Row Rivers*

**Storage Projects – Cottage Grove and Dorena**

Alternative 3A would have a major change in shoreline exposure relative to NAA at Cottage Grove and Dorena reservoirs due to changes in operational range. Deeper drafts expose additional shoreline to potential bank erosion and sediment entrainment. Deeper drafts also allow access to reservoir banks that were previously inundated.

Alternative 3A would have negligible change in the potential for head-of-reservoir sediment mobilization and sediment trap efficiency at Cottage Grove and Dorena reservoirs relative to the NAA.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a moderate change in sediment supply with additional fine-grained sediment passing into the Coast Fork Willamette and Row River free-flowing reaches from Cottage Grove and Dorena River from the NAA. Increased sediment supply is due deeper drafts in Cottage Grove and Dorena reservoirs that have the potential to induce bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume.

There is negligible potential for geomorphic change relative to the NAA in the Coast Fork of the Willamette River and Row River free-flowing reach.

#### *3.3.2.6.10 Evaluation of Near-Term Operations Measure*

See Alternative 2A, Section 3.3.2.4.10, for description of effects due to the Near-Term Operations Measure.

#### *3.3.2.6.11 Climate Change*

Alternative 3A would have negligible potential for change in sediment conditions due to climate change relative to the NAA in all reservoirs and reaches except Lookout Point, Dexter, Green Peter, Foster, Cougar, Detroit and Big Cliff dams. There are also potential climate change driven sediment effects in the McKenzie River downstream of Cougar Dam.

Deeper drafts at Lookout Point Dam have the potential to pass increased climate change driven fine-grained sediment into Dexter Reservoir, resulting in increased deposition in Dexter Reservoir and increased fine-grained sediment supply into the Middle Fork Willamette downstream of Dexter Dam.

Deeper drafts at Green Peter Dam have the potential to pass increased climate change driven fine-grained sediment into Foster Reservoir resulting in increased deposition in Foster Reservoir and increased fine-grained sediment supply into the South Santiam downstream of Foster Dam.

Deeper drafts at Cougar Dam have the potential to pass increased climate change driven fine-grained sediment into the South Fork McKenzie downstream of the dam.

Deeper drafts at Detroit Dam have the potential to pass increased climate change driven fine-grained sediment into Big Cliff Reservoir resulting in increased deposition in Big Cliff Reservoir and increased fine-grained sediment supply into the North Santiam downstream of Big Cliff Dam.

#### *3.3.2.6.12 Summary of Effects of Alternative 3A*

Table 3.3-5 shows the summary of effects under Alternative 3A.

**Table 3.3-5. Summary of effects for River Mechanics and Geomorphology under Alternative 3A Compared to the NAA**

| Subbasin | Alternative 3A |
|---|---|
| **General** | Effects to river mechanics and geomorphology metrics are none/negligible except those stated below. |
| **Santiam Subbasin** | Detroit storage project would have a major effect with a decrease in sediment trapping efficiency, major effect in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and major effect in shoreline exposure with more shoreline |

| Subbasin | Alternative 3A |
|---|---|
| | exposed due to changes in operational range and deeper drafts. Green Peter storage project would have a moderate effects with a decrease in sediment trapping efficiency, major effect in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and major effect in shoreline exposure with more shoreline exposed due to changes in operational range and deeper drafts.<br><br>Downstream of the storage projects, there is potential for a major effect with an increase in fine grained sediment supply into the Big Cliff and Foster re-regulation projects which would partially settle in the pools and in turn may pass a moderate increase in fine grained sediment downstream into the North and South Santiam free-flowing reaches.<br><br>Gravel augmentation below dams (#384) measure would have major effects to geomorphology downstream of Big Cliff and Foster dams and would modify the geomorphology of the North Fork Santiam and South Fork Santiam respectively. |
| **Long Tom Subbasin** | Negligible effects |
| **McKenzie Subbasin** | Cougar storage project would have a moderate effect with a decrease in sediment trapping efficiency, major effect in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and major effect in shoreline exposure with more shoreline exposed due to changes in operational range and deeper drafts. Blue River storage project would have a minor effects with decrease in sediment trapping efficiency, minor effect in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and major effect in shoreline exposure with more shoreline exposed due to changes in operational range and deeper drafts.<br><br>Downstream of the storage projects, there is potential for a moderate effect with an increase in fine grained sediment supply into the South Fork McKenzie and Blue Rivers from the reservoirs.<br><br>Gravel augmentation below dams (#384) measure would have major effects to geomorphology downstream of Big Cliff and Foster dams and would modify the geomorphology of the North Fork Santiam and South Fork Santiam respectively. |

| Subbasin | Alternative 3A |
|---|---|
| **Middle Fork of the Willamette Subbasin** | Lookout Point storage project would have a major effect with a decrease in sediment trapping efficiency, major effect in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and major effect in shoreline exposure with more shoreline exposed due to changes in operational range and deeper drafts. Hills Creek storage project would have minor effect in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and minor effect in shoreline exposure with more shoreline exposed due to deeper drafts.<br><br>Downstream of the storage projects, there is potential for a major effects with an increase in fine grained sediment supply into the Dexter re-regulation project which would partially settle in the pool and in turn may pass a moderate increase in fine grained sediment downstream into the Middle Fork Willamette free-flowing reach. |
| **Coast Fork of the Willamette Subbasin** | Dorena and Cottage Grove storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts.<br><br>Downstream of both storage projects, there is potential for a moderate effect with an increase in fine grained sediment supply into the Row River and Coast Fork Willamette. |
| **Mainstem Willamette River** | There is potential for a minor effects with an increase in fine grained sediment supply into the Mainstem Willamette River coming from changes in operation in the Middle and Coast Forks of the Willamette and McKenzie subbasins. |

### *3.3.2.7 Alternative 3B*

See Section 2.4.7 for a complete description of Alternative 3B. Alternative 3B effects are relative to the NAA and are summarized by impact type in this section. See Appendix C, Chapter 2 for metric calculations and supporting figures.

#### *3.3.2.7.1 Lower Willamette*

**<u>Run-of-River Reservoir and Free-Flowing Reaches</u>**

There is negligible potential for changes in sediment supply relative to the NAA in the Lower Willamette free-flowing reach relative to the NAA. There is negligible potential for geomorphic change relative to the NAA in the Lower Willamette free-flowing reach.

#### *3.3.2.7.2 Middle Willamette*

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a minor change in sediment supply with additional fine-grained sediment passing into the Middle Willamette free-flowing reach from the Upper Willamette as compared to the NAA. Increased sediment supply is due deeper drafts in Cougar Reservoir that would have the potential pass additional fine-grained sediment downstream.

There is negligible potential for geomorphic change relative to the NAA in the Middle Willamette free-flowing reach.

#### *3.3.2.7.3 Upper Willamette*

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a moderate change in sediment supply with additional fine-grained sediment passing into the Upper Willamette free-flowing reach from both the Coast Fork and Middle Fork Willamette relative to the NAA. Increased sediment supply is due deeper drafts in Cottage Grove, Dorena and Lookout Point reservoirs that have the potential pass additional fine-grained sediment downstream.

There is negligible potential for geomorphic change relative to the NAA in the Upper Willamette free-flowing reach.

#### *3.3.2.7.4 North Santiam*

**Storage Projects – Detroit Dam**

Alternative 3B would have the potential for major changes in shoreline exposure relative to NAA due to changes in operational range at Detroit Reservoir. Deeper drafts expose additional shoreline to potential bank erosion, sediment entrainment or even slope failures. Deeper drafts also allow access to banks that were previously inundated.

Alternative 3B would have the potential for major changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Detroit Reservoir. There is major potential for stored head-of-reservoir sediment to be re-mobilized and transported further into the reservoirs. Future head-of-reservoir deposition would likely deposit further into the reservoir than NAA. Potential changes in head-of-reservoir deposits are due to operations holding the reservoirs lower than NAA during higher inflow where sediment is mobilized and brought into the reservoir from upstream.

Alternative 3B would have the potential for minor changes in sediment trap efficiency with reduced trap efficiency relative to NAA at Detroit Reservoir. Potential changes in reservoir sediment trap efficiency are due to operations holding the reservoir lower than NAA, resulting in sufficiently lower reservoir storage volumes, during higher inflow where sediment is mobilized and brought into the reservoir from upstream. Reductions in trap efficiency would mean that a larger fraction of easily suspended, fine-grained sediment may stay in transport and pass these dams. This results in less deposition of these fine-grained sediments in the reservoir and conversely, large quantities of easily suspended, fine-grained sediments passing the reservoir downstream.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a moderate change in sediment supply with additional fine-grained sediment passing into Big Cliff run-of-river reservoir relative to the NAA. Increased sediment supply is due to deeper drafts in Detroit Reservoir. The primary mechanism that is causing the effect determination is deeper drafts in Detroit Reservoir that creates moderate potential for bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume. Additionally, there is a minor decrease in trapping efficiency at Detroit Reservoir where the dam passes additional inflowing sediment during high flow events. These additional fine-grained sediments that enter Big Cliff Reservoir may partially settle in the reservoir.

There is a major change in coarse-grained bed material sediment supply to the North Santiam free-flowing reach due to direct placement of bed material sized sediment through gravel augmentation below dams (#384) relative to the NAA. Additionally, there is potential for a minor change in fine-grained sediment supply to the North Fork Santiam River downstream of Big Cliff Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply is due deeper drafts in Detroit Reservoir that have the potential to pass sediment through Detroit Dam and partially through the Big Cliff run-of-river reservoir.

***Geomorphic Change Below Big Cliff***

There is major potential for geomorphic change in the North Santiam downstream of Big Cliff Dam due to the gravel augmentation below dams (#384) measure as compared to the NAA. Geomorphic effects below Big Cliff Dam as the same as Alternative 1. See the Section 3.3.2.3.4 for description of effects.

*3.3.2.7.5 South Santiam and Mainstem Santiam*

**Storage Projects – Green Peter and Foster**

Alternative 3B would have major changes in shoreline exposure relative to NAA due to changes in operational range at Green Peter Reservoir. Deeper drafts expose additional shoreline to potential bank erosion, sediment entrainment or even slope failures. Deeper drafts also allow access to banks that were previously inundated. Alternative 3B would have negligible change in shoreline exposure at Foster Reservoir.

Alternative 3B would have the potential for a major change in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Green Peter Reservoir. There is major potential for stored head-of-reservoir sediment to be re-mobilized and transported further into the reservoir. Future head-of-reservoir deposition would likely deposit further into the reservoir than NAA. Potential changes in head-of-reservoir deposits are due to operations holding the reservoirs lower than NAA during higher inflow where sediment is mobilized and brought into the reservoir from upstream.

Alternative 3B would have the potential for minor change in head-of-reservoir sediment mobilization relative to NAA in Foster Reservoir. This is due to changes in operations at Green Peter Reservoir upstream. Peak flows entering Foster Reservoir when the pool is drawn down are decreased, however there is an increase in fall flows when the reservoir is full. There is minor potential for future head-of-reservoir deposition to occur higher in the reservoir relative to NAA.

Head-of reservoir deposits are typically composed of the coarse-grained sediment supply (sand, gravels and any cobbles that may be in transport) but may also contain some of the coarser silts that can readily settle in the transition from flowing river to quiescent reservoir.

Alternative 3B would have the potential for major changes in sediment trap efficiency with reduced trap efficiency relative to NAA at Green Peter Reservoir. Alternative 3B would have negligible potential for changes in sediment trap efficiency relative to NAA at Foster Reservoir. Potential changes in reservoir sediment trap efficiency in all cases are due to operations holding the reservoirs lower than NAA, resulting in sufficiently lower reservoir storage volumes, during higher inflow where sediment is mobilized and brought into the reservoir from upstream. Reductions in trap efficiency would mean that a larger fraction of easily suspended, fine-grained sediment may stay in transport and pass these dams. This results in less deposition of these fine-grained sediments in the reservoir and conversely, large quantities of easily suspended, fine-grained sediments passing the reservoir downstream.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a major change in sediment supply with additional fine-grained sediment passing into Foster Reservoir as compared to the NAA relative to the NAA. Increased sediment supply is due to deeper drafts in Green Peter Reservoir. Deeper drafts in Green Peter Reservoir create major potential for bank erosion and sloughing, generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume. Additionally, there is a major decrease in trapping efficiency at Green Peter Reservoir where the dam passes additional inflowing sediment during high flow events. These additional fine-grained sediments that enter Foster Reservoir may partially settle in the reservoir.

There is a major change in coarse-grained bed material sediment supply to the South Santiam free-flowing reach due to direct placement of bed material sized sediment through gravel augmentation below dams (#384) as compared to the NAA. Additionally, there is potential for a moderate change in fine-grained sediment supply to the South Fork Santiam River downstream of Foster Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply is due deeper drafts in Green Peter Reservoir that have the potential to pass sediment through Detroit Dam and partially through the Foster run-of-river reservoir.

There is potential for a minor change in sediment supply with additional fine-grained sediment passing into the Mainstem Santiam free-flowing reach from the both the North Fork and South Fork Santiam Rivers. Increased sediment supply is due deeper drafts in Green Peter and Detroit reservoirs that have major potential pass additional fine-grained sediment downstream of the dams.

***Geomorphic Change in Foster Run-of-River Reservoir***

Due to the potential for a major change in fine-grained sediment supply into Foster Reservoir from Green Peter draw downs, observable changes in sedimentation rates in Foster Reservoir are likely as compared to the NAA. Trapping efficiency for Foster is calculated to be 67% meaning that a portion of the increased fine-grained sediment supply would likely get trapped in the reservoir. This deposition would likely appear as a thicker silt drape within the reservoir and areas along on the banks of Foster reservoir.

***Geomorphic Change Below Foster Dam***

There is major potential for geomorphic change in the South Santiam downstream of Foster Dam due to the gravel augmentation below dams (#384) measure. Geomorphic effects below Foster Dam as the same as Alternative 1. See Section 3.3.2.3.5 for description of effects.

*3.3.2.7.6 Tom River*

**Storage Projects – Fern Ridge**

Alternative 3B would have negligible change in the potential for shoreline exposure, head-of-reservoir sediment mobilization and sediment trap efficiency at Fern Ridge Reservoir.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is negligible potential for changes from the NAA in sediment supply relative to the NAA in the Long Tom River free-flowing reach. There is negligible potential for geomorphic change relative to the NAA in the Long Tom River free-flowing reach.

*3.3.2.7.7 McKenzie and Blue Rivers*

**Storage Projects – Cougar and Blue River**

Alternative 3B would have the potential for major changes in shoreline exposure relative to NAA due to changes in operational range at Cougar and Blue River reservoirs. Deeper drafts expose additional shoreline to potential bank erosion, sediment entrainment or even slope failures. Deeper drafts also allow access to banks that were previously inundated.

Alternative 3B would have the potential for major changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Cougar Reservoir. There is major potential for stored head-of-reservoir sediment to be re-mobilized and transported further into the reservoir. Future head-of-reservoir deposition would likely deposit further into the reservoir than NAA. Potential changes in head-of-reservoir deposits are due to operations holding the reservoirs lower than NAA during higher inflow where sediment is mobilized and brought into the reservoir from upstream.

Alternative 3B would have the potential for minor changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Blue River Reservoir. There is minor potential for stored head-of-reservoir sediment to be re-mobilized and transported further into the reservoir. Future head-of-reservoir deposition would likely deposit further into the reservoir than NAA. Potential changes in head-of-reservoir deposits are due to operations holding the reservoirs lower than NAA during higher inflow where sediment is mobilized and brought into the reservoir from upstream

Head-of reservoir deposits are typically composed of the coarse-grained sediment supply (sand, gravels and any cobbles that may be in transport) but may also contain some of the coarser silts that can readily settle in the transition from flowing river to quiescent reservoir.

Alternative 3B would have the potential for major changes in sediment trap efficiency with reduced trap efficiency relative to NAA at Cougar Reservoir. Alternative 3B would have the potential for minor changes in sediment trap efficiency with reduced trap efficiency relative to NAA at Blue River Reservoir. Potential changes in reservoir sediment trap efficiency in all cases are due to operations holding the reservoirs lower than NAA, resulting in sufficiently lower reservoir storage volumes, during higher inflow where sediment is mobilized and brought into the reservoir from upstream. Reductions in trap efficiency would mean that a larger fraction of easily suspended, fine-grained sediment may stay in transport and pass these dams. This results in less deposition of these fine-grained sediments in the reservoir and conversely, large quantities of easily suspended, fine-grained sediments passing the reservoir downstream.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is a major change in coarse-grained bed material sediment supply to the McKenzie River free-flowing reach below Cougar Dam due to direct placement of bed material sized sediment through gravel augmentation below dams (#384) relative to the NAA. Additionally, there is potential for a major change in fine-grained sediment supply to the McKenzie River downstream of Cougar Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply is due deeper draft in Cougar Reservoir that cause a major decrease in trapping efficiency and a major increase in the potential for bank erosion and sloughing generating sediment in the reservoir that may pass the dam due to a concurrent reduction in reservoir storage volume.

There is a major change in coarse-grained bed material sediment supply to the Blue River free-flowing reach below Blue River Dam due to direct placement of bed material sized sediment through gravel augmentation below dams (#384) as compared to the NAA. Additionally, there is potential for a moderate change in fine-grained sediment supply to the Blue River downstream of Blue River Dam with additional fine-grained sediment passing the dam. Increased fine-grained sediment supply is due deeper draft in Blue River Reservoir that cause a minor decrease in trapping efficiency and a moderate increase in the potential for bank erosion and sloughing generating sediment in the reservoir that may pass the dam due to a concurrent reduction in reservoir storage volume.

***Geomorphic Change Below Cougar Dam***

There is major potential for geomorphic change in the South Fork McKenzie downstream of Cougar Dam due to the gravel augmentation below dams (#384) measure and fine-grained passing Cougar Dam relative to the NAA. Sediment augmentation in the South Fork McKenzie River below Cougar Dam is proposed to maintain and enhance the existing high quality and quantity of habitat for Spring Chinook and Winter Steelhead developed in the reach since 2018. Gravel augmentation below dams (#384) would annually place an appropriate quantity of specifically sized and graded sediments into the river prior to seasonal high flows and spawning. The placed material would be distributed by the river during high flows and integrate itself into the existing anastomosing mosaic downstream established during prior river restoration activities. Sediments are expected to move slowly through the restoration reach and potentially store for longer periods of time as normative river process occur.

Because the armored plane bed condition of the river has already been addressed by restoration actions, the goal of the augmentation is to supply required sediment into an existing process-based floodplain reengagement action. The gradation classes of the augmentation would necessarily be more varied and smaller than a typical confined valley spawning gravel augmentation project.

River condition monitoring, along with gravel augmentation below dams (#384) that may change the quantity, size or injection location of sediment augmentation, would identify and respond to river changes to improve targeted habitat maintenance goals and limit adverse effects.

Due to the potential for a major change in fine-grained sediment supply from Cougar Dam draw downs, observable turbidity and deposition of fines is expected in the South Fork McKenzie and potentially main stem McKenzie downstream of the South Fork confluence as compared to the NAA.

***Geomorphic Change Below Blue River Dam***

There is major potential for geomorphic change in the Blue River and potentially in the mainstem McKenzie downstream of Blue River Dam due to the gravel augmentation below dams (#384) measure relative to the NAA. Geomorphic effects of gravel augmentation below Blue River Dam as the same as Alternative 1. See Section 3.3.2.3.7 for description of effects.

#### *3.3.2.7.8 Middle Fork of the Willamette River and Fall Creek*

**Storage Projects – Fall Creek, Lookout Point and Hills Creek**

Alternative 3B would have the potential for major changes in bank exposure relative to NAA due to changes in operational range at Lookout Point and Hills Creek reservoirs. Alternative 3B would have negligible change in shoreline exposure at Fall Creek Reservoir. Deeper drafts expose additional shoreline to potential bank erosion, sediment entrainment or even slope failures. Deeper drafts also allow access to banks that were previously inundated.

Alternative 3B would have the potential for major changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Lookout Point and Hills Creek reservoirs. There is major potential for stored head-of-reservoir sediment to be re-mobilized and transported further into the reservoir. Future head-of-reservoir deposition would likely deposit further into the reservoir than NAA. Potential changes in head-of-reservoir deposits are due to operations holding the reservoirs lower than NAA during higher inflow where sediment is mobilized and brought into the reservoir from upstream.

Alternative 3B would have negligible potential for changes in head-of-reservoir sediment mobilization relative to NAA due to changes in operations at Falls Creek Reservoir.

Head-of reservoir deposits are typically composed of the coarse-grained sediment supply (sand, gravels and any cobbles that may be in transport) but may also contain some of the coarser silts that can readily settle in the transition from flowing river to quiescent reservoir.

Alternative 3B would have the potential for minor changes in sediment trap efficiency with reduced trap efficiency relative to NAA at Lookout Point and Hills Creek reservoirs. Alternative 3B would have negligible potential for changes in sediment trap efficiency relative to NAA Fall Creek Reservoir. Potential changes in reservoir sediment trap efficiency are due to operations holding the reservoirs lower than NAA, resulting in sufficiently lower reservoir storage volumes, during higher inflow where sediment is mobilized and brought into the reservoir from upstream. Reductions in trap efficiency would mean that a larger fraction of easily suspended, fine-grained sediment may stay in transport and pass these dams. This results in less deposition of these fine-grained sediments in the reservoir and conversely, large quantities of easily suspended, fine-grained sediments passing the reservoir downstream.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is minor potential for changes in sediment supply relative to the NAA in the Middle Fork of the Willamette above Lookout Point Reservoir free-flowing reach. This potential increase in fine-grained sediment supply is due to deeper drafts in Hills Creek Reservoir during higher flows that reduce trapping efficiency.

There is potential for a major change in sediment supply into Dexter Reservoir with additional fine-grained sediment passing out of Lookout Point Dam run-of-river reservoir relative to the

NAA. Increased sediment supply is due to deeper drafts in Lookout Point Reservoir. The primary mechanism that is causing the effect determination is deeper drafts create major potential for bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume. These additional fine-grained sediments that enter Dexter Reservoir may partially settle in the reservoir.

There is potential for a moderate change in sediment supply with additional fine-grained sediment passing into the Middle Fork of the Willamette below Dexter Dam free-flowing reach as compared to the NAA. Increased sediment supply is due deeper drafts in Lookout Point Reservoir that would have potential pass additional fine-grained sediment downstream and partially through Dexter Reservoir.

There is negligible potential for changes in sediment supply relative to the NAA in the Fall Creek free-flowing reach downstream of Fall Creek Dam.

***Geomorphic Change in Dexter Run-of-River Reservoir***

Due to the potential for a major change in fine-grained sediment supply into Dexter Reservoir from Lookout Point draw downs, observable changes in sedimentation rates in Dexter Reservoir are likely relative to the NAA. Trapping efficiency for Dexter is calculated to be 51% meaning that a portion of the increased fine-grained sediment supply would likely get trapped in the reservoir. This deposition would likely appear as a thicker silt drape within the reservoir and areas along on the banks of Dexter reservoir.

*3.3.2.7.9 Coast Fork of the Willamette River and Row Rivers*

**Storage Projects – Cottage Grove and Dorena**

Alternative 3B would have a major change in shoreline exposure relative to NAA at Cottage Grove and Dorena reservoirs due to changes in operational range as compared to the NAA. Deeper drafts expose additional shoreline to potential bank erosion and sediment entrainment. Deeper drafts also allow access to reservoir banks that were previously inundated.

Alternative 3B would have negligible change in the potential for head-of-reservoir sediment mobilization and sediment trap efficiency at Cottage Grove and Dorena reservoirs.

**Run-of-River Reservoir and Free-Flowing Reaches**

There is potential for a moderate change in sediment supply with additional fine-grained sediment passing into the Coast Fork Willamette and Row River free-flowing reaches from Cottage Grove and Dorena River. Increased sediment supply is due deeper drafts in Cottage Grove and Dorena reservoirs that have the potential to induce bank erosion and sloughing generating sediment that may pass the dam due to a concurrent reduction in reservoir storage volume.

There is negligible potential for geomorphic change relative to the NAA in the Coast Fork of the Willamette River and Row River free-flowing reach.

##### *3.3.2.7.10 Evaluation of Near-Term Operations Measure*

See Alternative 2A, Section 3.3.2.4.10, for description of effects due to the Near-Term Operations Measure.

##### *3.3.2.7.11 Climate Change*

Alternative 3B would have negligible potential for change from the NAA in sediment conditions due to climate change relative to the NAA in all reservoirs and reaches except Hills Creek, Lookout Point, Dexter, Green Peter, Foster, Cougar, Detroit and Big Cliff dams. There are also potential climate change driven sediment effects in the McKenzie River downstream of Cougar Dam and Middle Fork Willamette downstream of Hills Creek Dam.

Deeper drafts at Hills Creek Dam have the potential to pass increased climate change driven fine grained sediment in the Middle Fork Willamette downstream of the dam.

Deeper drafts at Lookout Point Dam have the potential to pass increased climate change driven fine-grained sediment into Dexter Reservoir, resulting in increased deposition in Dexter and increased fine-grained sediment supply to the Middle Fork Willamette downstream of Dexter Dam.

Deeper drafts at Green Peter Dam have the potential to pass increased climate change driven fine-grained sediment into Foster Reservoir, resulting in increased deposition in Foster Reservoir and increased fine-grained sediment supply into the South Santiam downstream of Foster Dam.

Deeper drafts at Cougar Dam have the potential to pass increased climate change driven fine grained sediment into the South Fork McKenzie downstream of the dam.

Deeper drafts at Detroit Dam have the potential to pass increased climate change driven fine-grained sediment into Big Cliff Reservoir, resulting in increased deposition in Big Cliff Reservoir and increased fine-grained sediment supply to the North Santiam downstream of Big Cliff Dam.

##### *3.3.2.7.12 Summary of Effects of Alternative 3B*

Table 3.3-6 shows the summary of effects under Alternative 3B.

**Table 3.3-6. Summary of effects for River Mechanics and Geomorphology under Alternative 3B Compared NAA**

| Subbasin | Alternative 3B |
|---|---|
| **General** | Effects to river mechanics and geomorphology metrics are none/negligible except those stated below. |
| **Santiam Subbasin** | Detroit storage project would have a minor effects with a decrease in sediment trapping efficiency, major effect in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and major effect in shoreline exposure with more shoreline exposed due to changes in operational range and deeper drafts. Green Peter storage project would have a major effect with a decrease in sediment trapping efficiency, major effect in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and major effect in shoreline exposure with more shoreline exposed due to changes in operational range and deeper drafts.<br><br>Downstream of the storage projects, there is potential for a moderate effect with an increase in fine grained sediment supply into the Big Cliff re-regulation project which would partially settle in the pools and in turn may pass a minor increase in fine grained sediment downstream into the North Santiam free-flowing reach. There is potential for a major effect with an increase in fine grained sediment supply into the Foster re-regulation project which would partially settle in the pools and in turn may pass a moderate increase in fine grained sediment downstream into the South Santiam free-flowing reach.<br><br>Gravel augmentation below dams (#384) measure would have major effects to geomorphology downstream of Big Cliff and Foster dams and would modify the geomorphology of the North Fork Santiam and South Fork Santiam respectively. |
| **Long Tom Subbasin** | Negligible effects |
| **McKenzie Subbasin** | Cougar storage project would have a major effect with a decrease in sediment trapping efficiency, major effect in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and major effect in shoreline exposure with more shoreline exposed due to changes in operational range and deeper drafts. Green Peter storage project would have a minor effect with a decrease in sediment trapping efficiency, minor effect in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and major effect in shoreline exposure with more |

| Subbasin | Alternative 3B |
|---|---|
| | shoreline exposed due to changes in operational range and deeper drafts.<br><br>Downstream of the storage projects, there is potential for a major effect with an increase in fine grained sediment supply into the South Fork McKenzie and a moderate increase of fine-grained sediment supply into Blue River from the reservoirs.<br><br>Gravel augmentation below dams (#384) measure would have major effects to geomorphology downstream of the South Fork McKenzie and Blue River dams and would modify the geomorphology of the South Fork McKenzie and Blue River respectively. The potential major increase in sediment in fine grained sediment supply form Cougar reservoir may deposit substantial fines in the South Fork McKenzie. |
| **Middle Fork of the Willamette Subbasin** | Lookout Point and Hills Creek storage projects would have a minor effect with a decrease in sediment trapping efficiency, major effect in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir and major effect in shoreline exposure with more shoreline exposed due to changes in operational range and deeper drafts.<br><br>Downstream of the storage projects, there is potential for a major effect with an increase in fine grained sediment supply into the Dexter re-regulation project which would partially settle in the pool and in turn may pass a moderate increase in fine grained sediment downstream into the Middle Fork Willamette free-flowing reach. There is potential for a minor effect with an increase in fine grained supply into the Middle Fork Willamette from Hills Creek reservoir. |
| **Coast Fork of the Willamette Subbasin** | Dorena and Cottage Grove storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts.<br><br>Downstream of both storage projects, there is potential for a moderate effect with an increase in fine grained sediment supply into the Row River and Coast Fork Willamette. |
| **Mainstem Willamette River** | There is potential for a moderate effect with an increase in fine grained sediment supply into the Mainstem Willamette River coming from changes in operation in the Middle and Coast Forks of the Willamette and McKenzie subbasins. |

### *3.3.2.8 Alternative 4*

See Section 2.4.8 for a complete description of Alternative 4. Alternative 4 effects are the same as Alternative 1 for the resource area. Refer to impact descriptions in Alternative 1, Section 3.3.2.3 for all Alternative 4 regions and effects. See Appendix C, Chapter 2 for metric calculations and supporting figures.

#### *3.3.2.8.1 Evaluation of Near-Term Operations Measure*

See Alternative 2A, Section 3.2.2.4.10, for description of effects due to the Near-Term Operations Measure.

#### *3.3.2.8.2 Climate Change*

Alternative 4 would have negligible potential for change in sediment conditions due to climate change relative to the NAA.

#### *3.3.2.8.3 Summary of Effects of Alternative 4*

Table 3.3-7 shows the summary of effects under Alternative 4.

**Table 3.3-7. Summary of effects for River Mechanics and Geomorphology under Alternative 4**

| Subbasin | Alternative 4 |
|---|---|
| **General** | Effects to river mechanics and geomorphology metrics are none/negligible except those stated below. |
| **Santiam Subbasin** | Detroit and Green Peter storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts.<br><br>Downstream of the storage projects, there is potential for a moderate effect with an increase in fine grained sediment supply into the Big Cliff and Foster re-regulation projects which in turn may pass a minor increase in fine grained sediment downstream into the free-flowing reaches.<br><br>Gravel augmentation below dams (#384) measure would have major effects to geomorphology downstream of Big Cliff and Foster dams and would modify the geomorphology of the North Fork Santiam and South Fork Santiam respectively. |
| **Long Tom Subbasin** | Negligible effects |
| **McKenzie Subbasin** | Cougar and Blue River storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts. |

| Subbasin | Alternative 4 |
| --- | --- |
| | Downstream of the storage projects, there is potential for a minor effects with an increase in fine grained sediment supply into the South Fork McKenzie and a moderate increase of fine-grained sediment supply into Blue River.<br><br>Gravel augmentation below dams (#384) measure would have major effects to geomorphology downstream of Big Cliff and Foster dams and would modify the geomorphology of the North Fork Santiam and South Fork Santiam respectively. |
| **Middle Fork of the Willamette Subbasin** | Hills Creek and Lookout Point storage projects would have major effects with changes in shoreline exposure due to changes in operational range and deeper drafts.<br><br>Downstream of the storage projects, there is potential for a moderate effects with an increase in fine grained sediment supply below Hills Creek and a minor increase in fine-grained sediment supply below Lookout Point entering Dexter Reservoir. |
| **Coast Fork of the Willamette Subbasin** | Dorena and Cottage Grove storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts.<br><br>Downstream of both storage projects, there is potential for a moderate effects with an increase in fine grained sediment supply into the Row River and Coast Fork Willamette. |
| **Mainstem Willamette River** | Negligible effects |

### *3.3.2.9 Alternative 5*

See Section 2.4.9 for a complete description of Alternative 5. Alternative 5 effects are the same as Alternative 2B for the resource area. Refer to impact descriptions in Alternative 2B, Section 3.3.2.5 for all Alternative 5 regions and effects. See Appendix C, Chapter 2 for metric calculations and supporting figures.

#### *3.3.2.9.1 Evaluation of Near-Term Operations Measure*

See Alternative 2A, Section 3.2.2.4.10, for description of effects due to the Near-Term Operations Measure.

#### *3.3.2.9.2 Climate Change*

Alternative 5 climate change effects are the same as Alternative 2B for the resource area. Refer to Section 3.3.2.5.5 for all Alternative 5 climate change discussion.

### *3.3.2.9.3 Summary of Effects of Alternative 5*

Table 3.3-8 shows the summary of effects under Alternative 5.

**Table 3.3-8. Summary of effects for River Mechanics and Geomorphology under Alternative 5 as Compared to the NAA**

| Subbasin | Alternative 5 |
|---|---|
| **General** | Effects to river mechanics and geomorphology metrics are none/negligible except those stated below. |
| **Santiam Subbasin** | Detroit and Green Peter storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts. Additionally, Green Peter would have moderate effects with decreases in sediment trap efficiency and major changes in head-of-reservoir sediment mobility with more sediment depositing further into the reservoir.<br><br>Downstream of the storage projects, there is potential for a moderate effects with an increase in fine grained sediment supply into the Big Cliff re-regulation project which in turn may pass a minor increase in fine grained sediment downstream into the North Santiam free-flowing reach. There is potential for a major effects with an increase in fine grained sediment supply to Foster reservoir from Green Peter which in partially settle in the Foster pool and in turn may pass a moderate increase in fine grained sediment supply downstream into the South Santiam.<br><br>Gravel augmentation below dams (#384) measure would have major effects to geomorphology downstream of Big Cliff and Foster dams and would modify the geomorphology of the North Fork Santiam and South Fork Santiam respectively. |
| **Long Tom Subbasin** | Negligible effects |
| **McKenzie Subbasin** | Cougar and Blue River storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts. Additionally, the Cougar storage project would have major effects with decreased sediment trapping efficiency and changes in head of reservoir sediment mobilization with sediment deposition deeper in the reservoir.<br><br>Downstream of the storage projects, there is potential for a major effects with an increase in fine grained sediment supply into the South Fork McKenzie and a moderate effects with an increase of fine-grained sediment supply into Blue River from the reservoirs. |

| Subbasin | Alternative 5 |
|---|---|
| | Gravel augmentation below dams (#384) measure would have major effects to geomorphology downstream of the South Fork McKenzie and Blue River dams and would modify the geomorphology of the South Fork McKenzie and Blue River respectively. |
| **Middle Fork of the Willamette Subbasin** | Hills Creek and Lookout Point storage projects would have major effects in shoreline exposure due to changes in operational range and deeper drafts.<br><br>Downstream of the storage projects, there is potential for a moderate effect with an increase in fine grained sediment supply below Hills Creek and a minor increase in fine-grained sediment supply below Lookout Point entering Dexter Reservoir. |
| **Coast Fork of the Willamette Subbasin** | Negligible effects |
| **Mainstem Willamette River** | There is potential for a moderate effect with an increase in fine grained sediment supply entering the mainstem Willamette from the McKenzie River due to changes in operations at Cougar Dam. |

## 3.4 GEOLOGY

### 3.4.1 Affected Environment

The affected environment for geology includes dam foundations, the areas around dams and reservoirs, and all relevant features that were described in each dam's periodic inspection. It also includes the active channel of the river up to the 1% and 0.2% Annual Exceedance Probability (AEP) flood elevation (100 and 500-year flood zones, respectively) for all reaches in the Willamette Valley that contain levees and bank protection works (Figure 3.4-1).

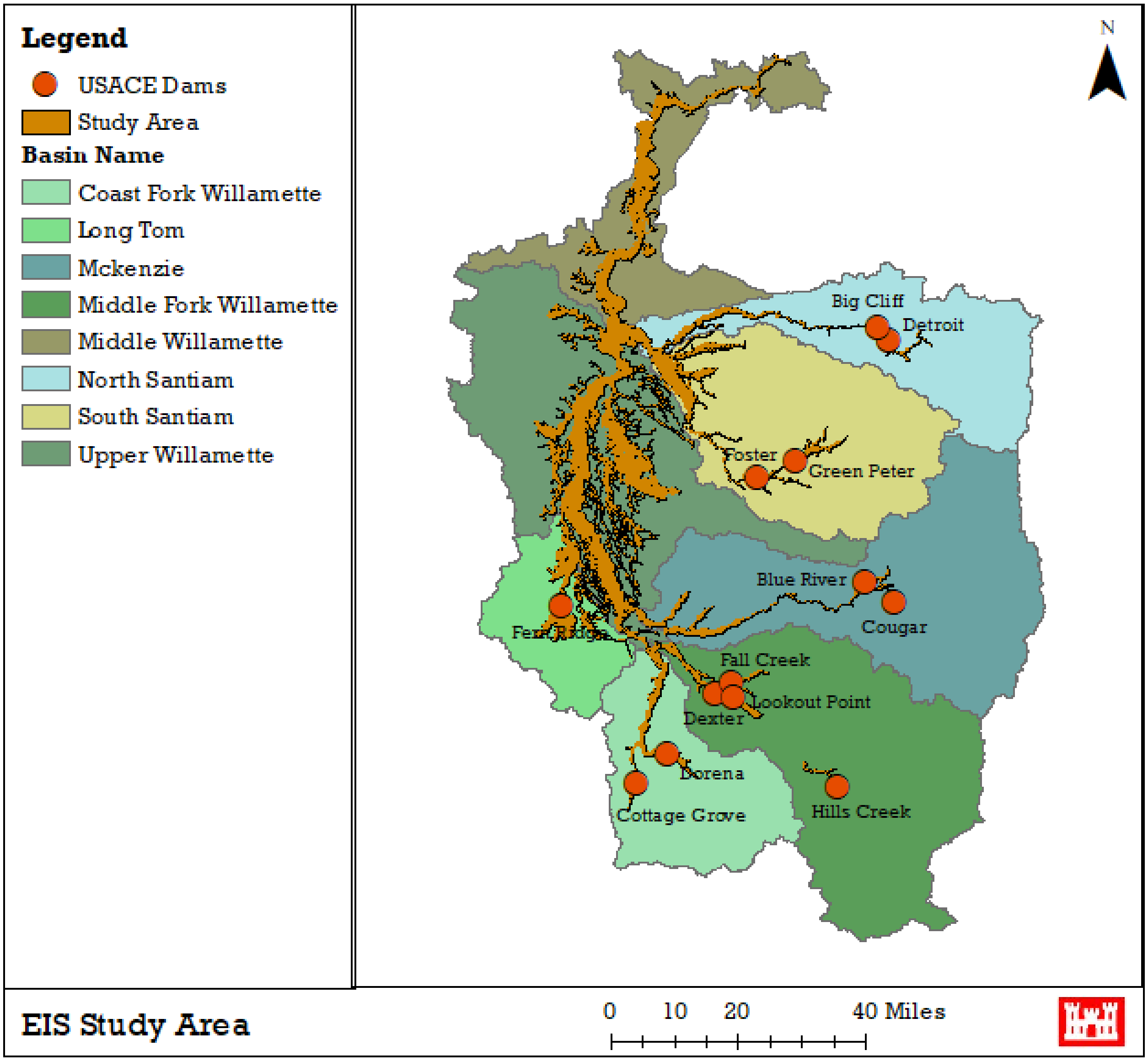



**Figure 3.4-1. Study Areas for the Willamette Valley PEIS**

### *3.4.1.1 Basin Wide*

#### *3.4.1.1.1 Geologic Physiographic Regions*

Western Oregon geology is the product of the Cascadia Subduction Zone (CSZ) and associated arc volcanism, which forms the major geologic regions in the area. The Willamette Valley hosts two provinces and three regions that have common topography, rock types and structure, and geologic and geomorphic history. These include the Middle Cascade Mountains region of the Cascade-Sierra mountains province and the Pacific Border province that is subdivided into the Puget Trough section (Willamette Valley) and Oregon Coast Range section (Fenneman and Johnson, 1946).

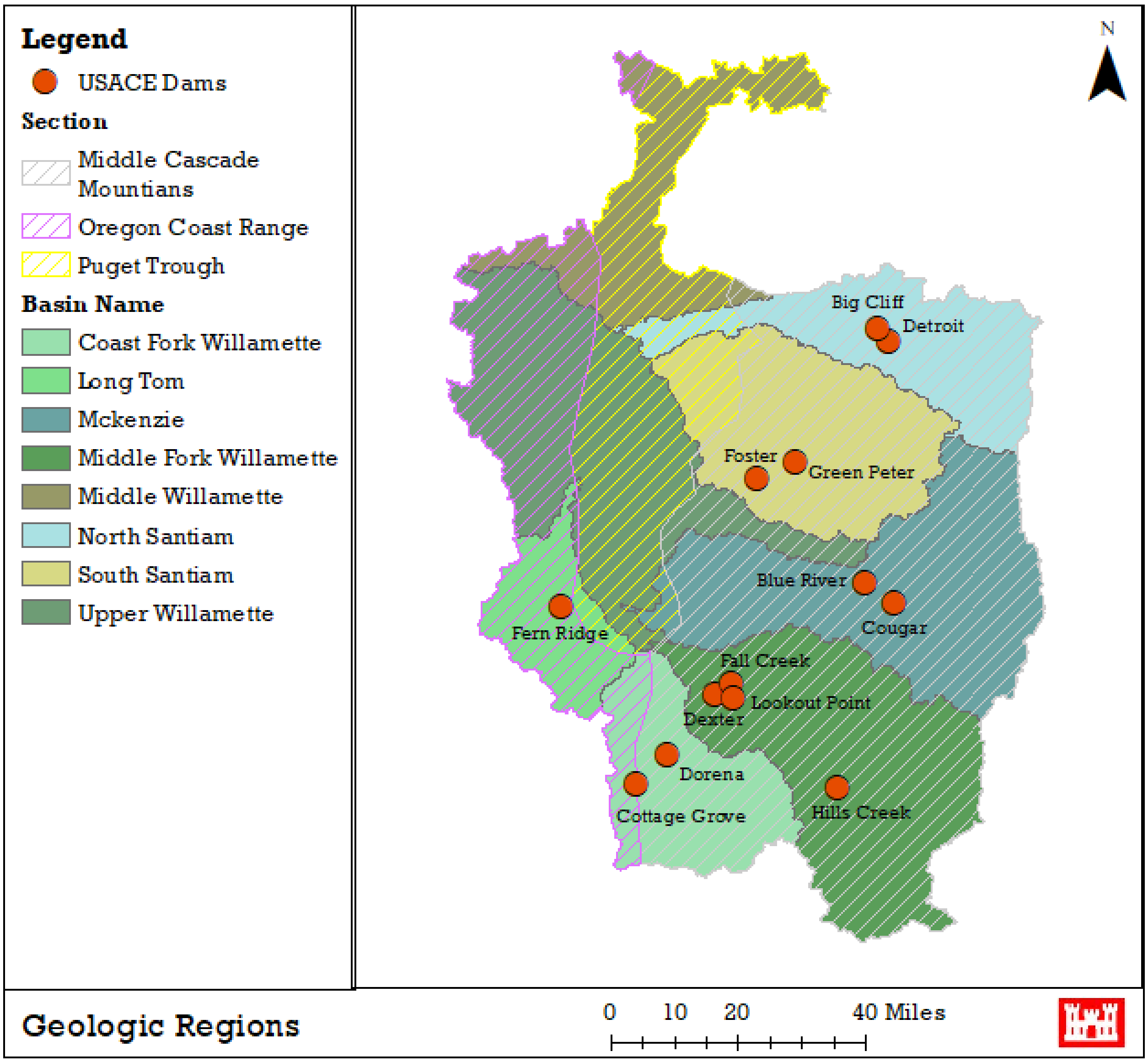



**Figure 3.4-2. Geologic Physiographic Regions of the Willamette Basin**

Source: Fenneman and Johnson, 1946

**Cascades**

The Cascades is a volcanic belt of rocks that extend from the Sierra Nevada in northern California to the Coast Mountains in British Columbia. The volcanic belt is about 80 miles wide in Washington and northern Oregon, but it narrows to about 40 to 50 miles in California. As shown in Figure 3.4-3, the range is frequently subdivided to two subprovinces, the Western Cascades and the High Cascades (Sherrod and Smith, 2000; **Error! Reference source not found.**). The Western Cascades is the older Tertiary inactive volcanic belt and forms the base of the range. The second subprovince is the High Cascades which is an active volcanic belt. The Cascades is a thick sequence 15,000 to 30,000 feet of volcanic rock. The composition of volcanic rocks ranges from basaltic to rhyolitic lava flows which are interbedded with explosive pyroclastic fragmental rocks (tuffs, breccias, lapilli tuffs, tuffaceous, ashflows, sandstone, siltstone and conglomerate). Most of the rocks in the Western Cascades have a slight hydrothermal alteration from the intrusion of monzonitic and dioritic sills and dikes in the late Miocene. The volcanic rocks are broken into numerous formations based on similar lithologic characteristics (USACE, 2017b).

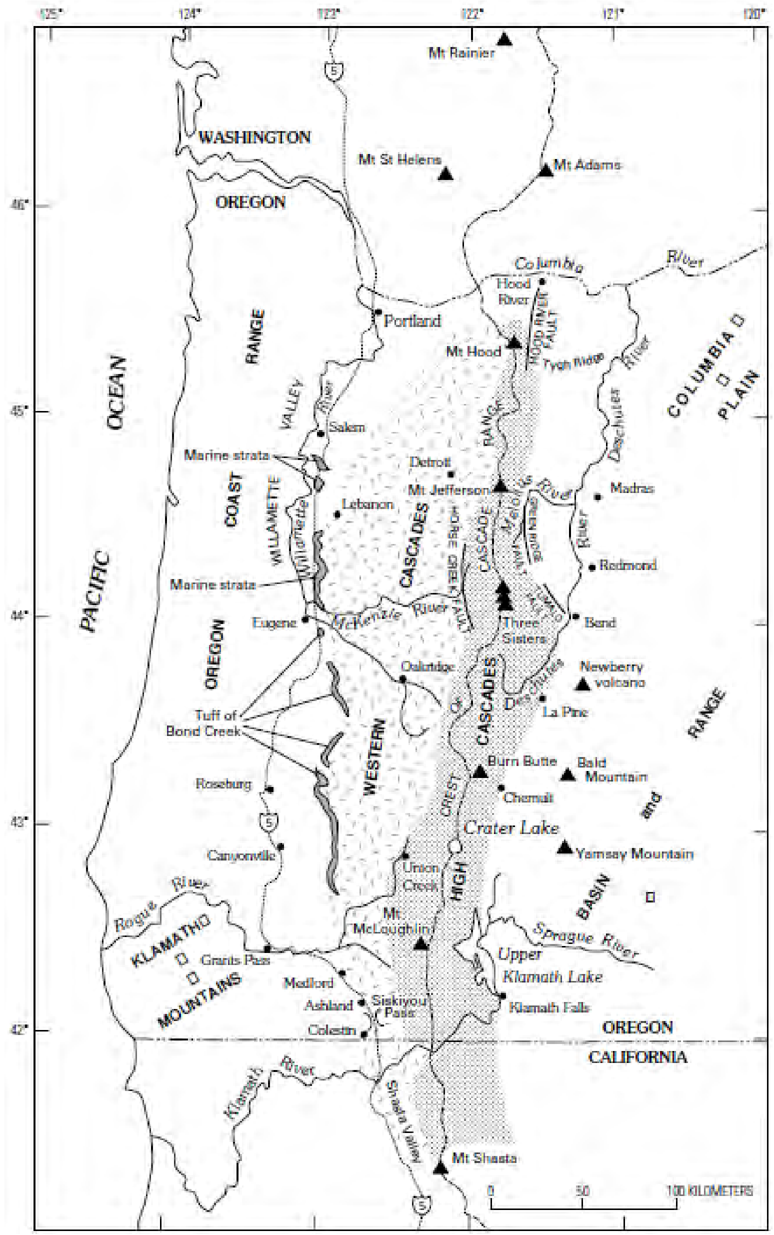



**Figure 3.4-3. Distribution of the Western and High Cascades**
Source: Sherrod and Smith, 2000)

## Oregon Coast Range and Puget Trough

The Oregon Coast Range is derived from continental arc volcanism and the accretion of marine rocks and sediments along the CSZ (McClaughry et al., 2010). Along with the volcanic rocks of the Western Cascades, it forms the basement of the Puget Trough, which is an elongated forearc basin that extends from the Puget Sound Lowland in Washington south to central Oregon (Vaccaro, 1997).

The Paleocene and Eocene mid-ocean ridge pillow basalts of the Siletz River formation form the basement of the Coast Range. The Kings Valley Formation is a siltstone containing volcanic grains from the Siletz River Formation and is interbedded in places with Siletz River volcanics.

The Eocene age Tyee Formation unconformably overlays the Siletz River Formation and contains sandstone turbidites deposited in a submarine fan and slope environment. The middle Eocene Spencer Formation includes marine sediments ranging in size from sandstone and conglomerate to sandstone and siltstone higher in the formation. It fines northward from near shore marine delta and shelf deposits near Eugene to deep water siltstone and claystone facies. The shallow-water marine deposits of the upper Eocene and Oligocene Eugene Formation overlay the Spencer Formation and contain marine sandstone, tuffaceous sandstone and siltstone, and pebbly conglomerate.

Both the Spencer and Eugene formations are interlayered with middle and upper Eocene aged nonmarine volcaniclastic sedimentary rocks, silicic tuff, and mafic lava strata of the Fisher Formation. The Eugene Formation also interfingers with the upper Eocene and lower Oligocene Keasy Formation which is composed of marine siltstone and tuffaceous siltstone and mudstone formed from volcanic lithics. The Paleocene- to lower Miocene-aged rocks are cut by a series of upper Eocene to middle-upper Miocene mafic to intermediate composition intrusive bodies including the Oligocene-aged gabbro and diorite dikes and sills of the Mary's Peak Intrusives, which form the highest peak in the coast range (McClaughry et al., 2010).

Tectonic activity during the Miocene and Pliocene uplifted the Coast Range and depressed the Puget Trough, forming a back-arc basin. During the Miocene the Columbia River Basalt Group (CRBG) lava flows entered the basin, forming the bedrock of the valley. Sediments from both the Coast and Cascade Mountain ranges and the Columbia River filled the depression.

Sediment from the Coast Range is generally clay, silt, and fine sand from weathering and erosion of marine sedimentary rocks. Sediment from the Cascades is composed of coarse sand and gravel-sized volcanic clasts. Sediments from the Columbia River are predominately derived from glacial outwash floods and include exotic quartzite, and granitic and metamorphic clasts lithologies. The Missoula Flood deposits are thicker and more extensive in the Portland Basin, but extend south past Eugene within the Willamette Basin.

Volcanic activity near Portland in the late Pliocene to early Pleistocene formed the Boring Lava Field, which contains shield volcanoes that are typically 100 to 200 feet thick but can be more than 600 feet thick. Holocene-aged alluvium in the floodplains of major streams of the foothills in the southern and central Willamette Valley predominantly contain tens of feet of sand and gravel-sized grains with some silt- and clay-sized particles. Smaller tributaries consist primarily of sand-to-clay size alluvial material. Along the Willamette River alluvium becomes progressively finer grained and thicker downstream, consisting primarily of 50-100 feet of sand and silt near Portland (Vaccaro, 1997).

#### *3.4.1.1.2 Seismicity*

The CSZ is a convergent boundary between the North America plate and the Juan de Fuca/Gorda plates from northernmost California to southernmost British Columbia. A major subduction zone “interplate” earthquake with a magnitude ($M_W$) between 8.5 and 9.2 on the Richter scale is believed to have occurred about once every 450 to 550 years (USACE, 2017d). More frequent events of smaller magnitudes (8.0 $M_W$) could occur every 200 years along the southern Oregon coast, resulting in strong ground shaking extending inland to the Willamette Valley. The last event occurred over 300 years ago on 26 January, 1700 (USACE, 2016b). The CSZ represents the main seismic source hazard for the Willamette Valley projects.

Other types of seismic events that may occur in western Oregon are deep subcrustal earthquakes that occur in the subducting slab typically at depths between 25 and 62+ miles, and crustal sources occurring within the North American plate (both along known faults and random seismicity not associated with any known faults).

The other type of earthquakes associated with the CSZ include “intraplate” earthquakes which occur within the subducting Juan de Fuca Plate. These earthquakes are generally quite deep with focal depths of 25 miles or more. The largest historical intraplate earthquakes recorded in the Pacific Northwest were the $M_W$ 7.1 Olympia earthquake in 1949, the $M_W$ 6.8 Nisqually earthquake northeast of Olympia in 2001, and the $M_W$ 6.5 Seattle-Tacoma earthquake in 1965. An intraplate event would likely have an epicenter located along the eastern margin of the Coast Range and possibly beneath the Willamette Valley (USACE, 2017d).

### *3.4.1.2 Coast Fork Willamette River*

#### *3.4.1.2.1 Basin Overview*

The Coast Fork Willamette River study area straddles the Cascades and Coast Range south of the Puget Trough. Unconsolidated deposits make up 81% of the surface area within the 1% AEP floodplain and 99% of the surface area within the 0.2% AEP floodplain. The majority of bedrock in the study area belongs to the Colestin Formation, which is the exposed oldest unit and is typically interfingered with the Eugene Formation; both are overlayed by the Little Butte Volcanics. The Colestin Formation is Eocene- and Oligocene-aged Early Western Cascade Volcanics including the andesite and volcanoclastic sedimentary rocks and tuff of the Fisher Formation and basalt (Hoover, 1963). The upper Eocene and Oligocene Eugene Formation is shallow-water marine deposits containing marine sandstone within the Coast Fork Willamette subbasin study area (McClaughry et al, 2010). The Little Butte Volcanics unit are composed of tuffs and basalt and andesite flows within the study area (Peck, 1964). There are no major quaternary faults or folds recorded in the study area.

#### *3.4.1.2.2 Dorena Dam*

In the immediate vicinity of Dorena Dam (Figure 3.4-4), the ground surface elevations range from approximately 1,200 to 2,000 feet. Lithologies near the reservoir consist of a varied and complex stratified volcanic sequence which includes basalt flows, well-bedded tuffaceous sandstones, tuffaceous pebble to cobble conglomerates, andesite flows and intrusions, tuffs, tuff breccias, and conglomeratic tuffs. Bedrock dips generally 30 degrees towards the east (upstream) and is cut by small basaltic andesite dikes, irregular intrusions and a large northwest trending fault zone.

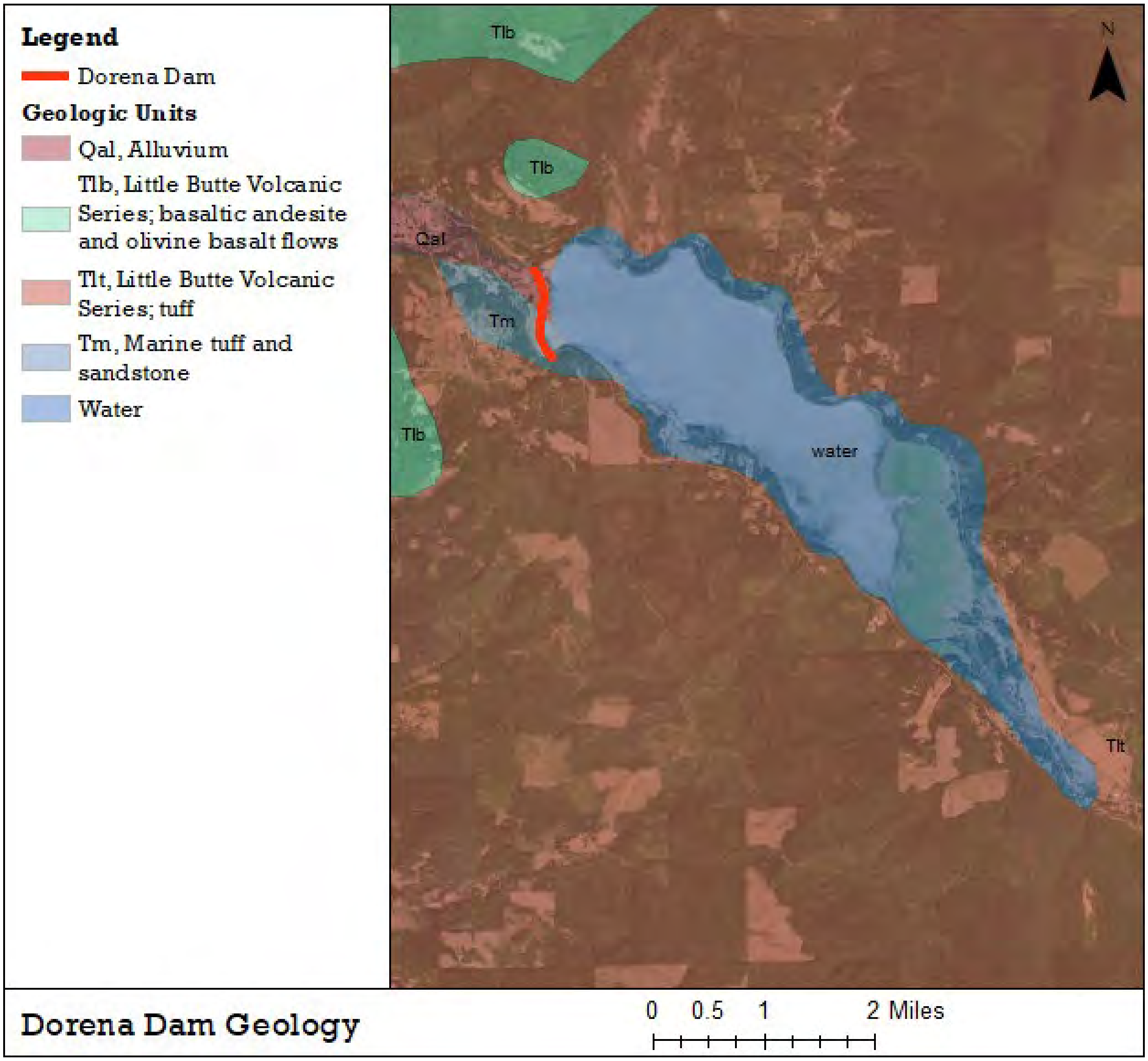



**Figure 3.4-4. Geologic Formations and Alluvial Deposits around Dorena Dam**

Source: Peck, 1964)

The valley floor is composed of approximately 10 to 20 feet of Quaternary river-deposited alluvium overlying bedrock. The upper layer of alluvium near the damsite is an average of 4 feet of low strength plastic clay and silt, underlain by approximately 15 feet of stratified alluvium containing 3-inch minus fraction gravel with 10-20% clay and silt with boulders. The foundation rock beneath the dam is predominantly andesite with some lapilli tuff and coarse tuff breccia. Foundation bedrock below the concrete structures consists almost entirely of massive andesite flow rock (USACE, 2017d). A large (32 million square feet) landslide is located immediately upstream of the dam (Walker, 2002).

### *3.4.1.2.3 Cottage Grove*

Cottage Grove Dam (Figure 3.4-5) and reservoir is located within the Middle Cascades physiographic section near the boundary with the Oregon Coast Range. The foothills of the Cascade Range are to the east of the dam and the Coast Range to the west. Relief ranges up to about 1500 feet on both sides of the lake. The immediate lake area has eroded terrain with gently sloping to partially rounded hills. The closest mapped Quaternary fault to the site is an unnamed fault located near Sutherlin, approximate 12 miles east of the site. The Cascadia Subduction Zone is 45 to 75 miles west of Cottage Grove Dam (USACE, 2017b).

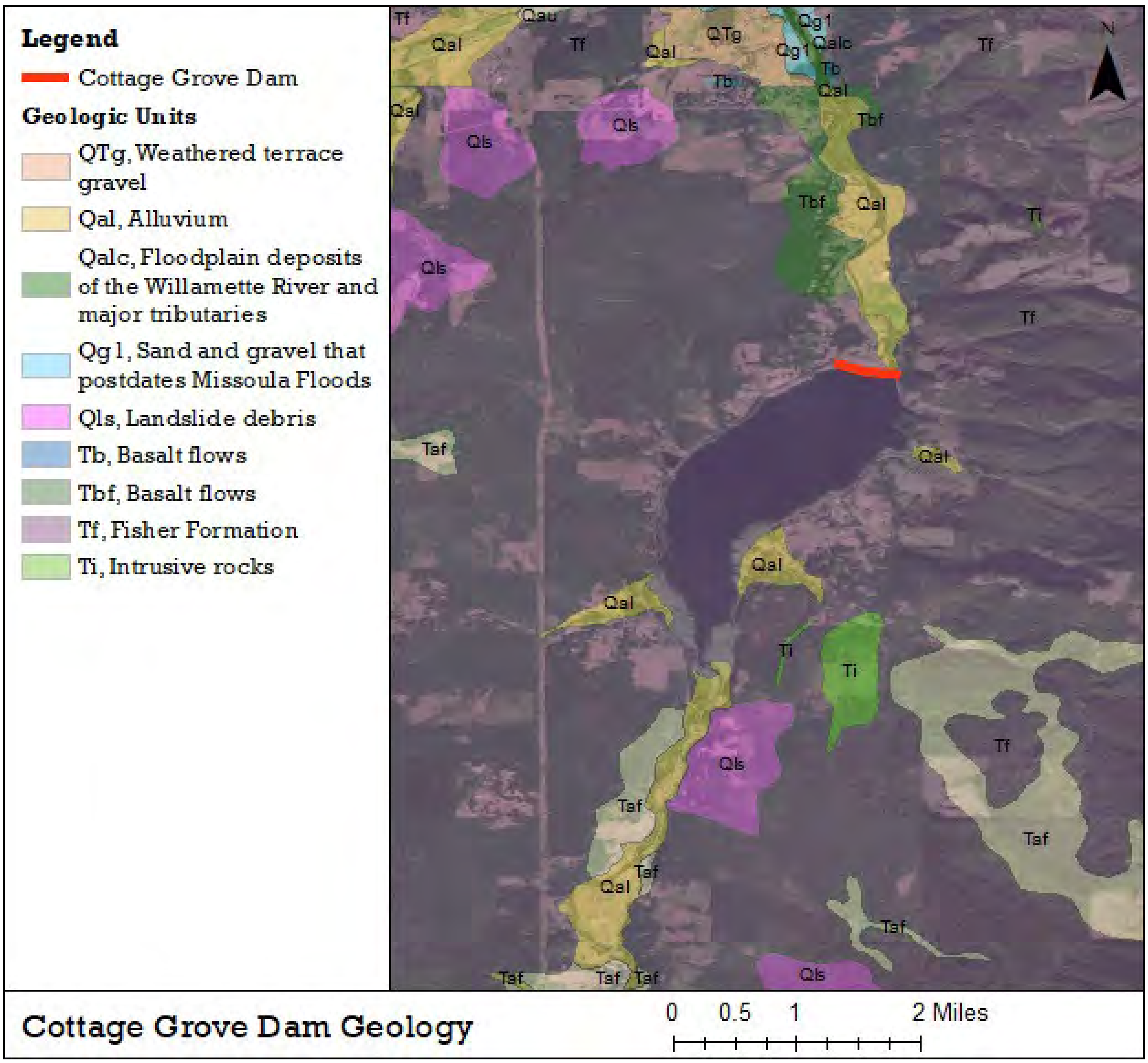



**Figure 3.4-5. Geologic Formations and Alluvial Deposits around Cottage Grove Dam**

Source: Hoover, 1963

#### *3.4.1.3 Long Tom*

##### *3.4.1.3.1 Basin Overview*

The Long Tom Basin is an elongated structural basin filled with thick accumulations of silt-clay, fresh sand, gravel and cobble deposits, and partly decomposed sand, gravel and cobbles (USACE, 2015e). The 1% AEP and 0.2% AEP floodplains are dominated by quaternary-aged unconsolidated deposits, which make up 99% of the 1% AEP floodplain and 100% of the 0.2% AEP floodplain. Eocene-aged deltaic sandstones of the Spencer Formation make up 1% of the 100-year floodplain within the study area and minor areas (<15 acres) of the Eugene Formation and Colestin Formations are present (McClaughry et al., 2010). There are no major quaternary faults or folds recorded in the study area.

##### *3.4.1.3.2 Fern Ridge*

Fern Ridge Dam (Figure 3.4-6) is located in the Oregon Coast Range physiographic section near the southern end of the Puget Trough (Willamette Valley). Rock formations underlying Fern Ridge Lake are exposed in adjacent foothills. Rock strata typically have low eastward dips of 10 to 20 degrees. Foundation materials beneath the Fern Ridge embankment consists of a thin clay blanket, underlain by a thin layer of silty sand, which overlies clayey gravels that extend 80 to 100 feet to bedrock. Foundation rocks are primarily marine tuffaceous sandstones and agglomerates that are intruded by diabase sills and dikes; there are some inter-bedded continental clastic tuffs and breccias to the southeast. West of the spillway, the embankment sits on highly weathered diabase. The spillway is founded on diabase rock (USACE, 2015e).

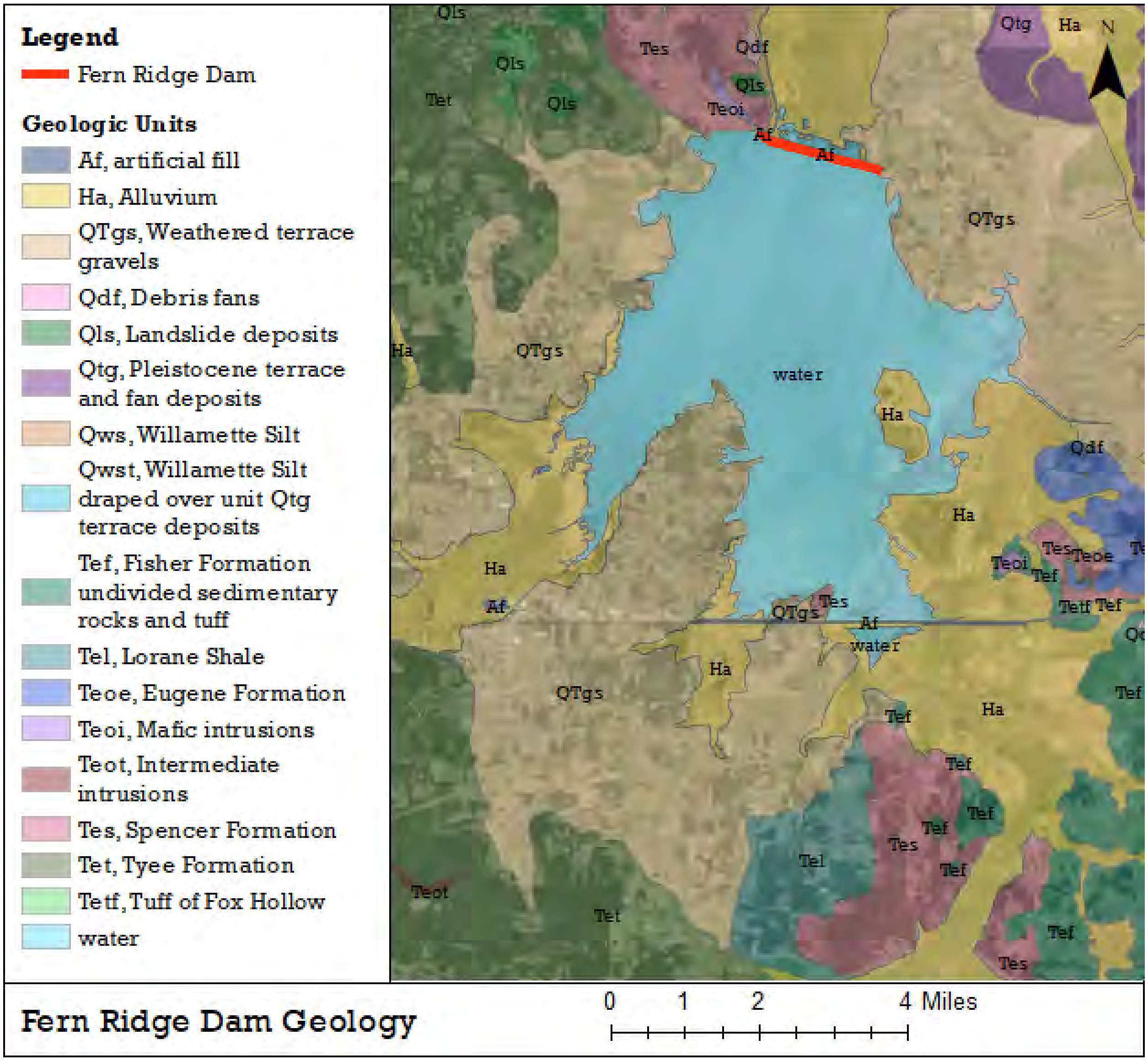



**Figure 3.4-6. Geologic Units in the Vicinity of Fern Ridge Dam**

Source: McClaughry et al., 2010

### *3.4.1.4 McKenzie Subbasin*

#### *3.4.1.4.1 Basin Overview*

In the McKenzie River subbasin unconsolidated deposits make up 95% of the 1% AEP floodplain and 70% of the 0.2% AEP floodplain. Primary surficial bedrock within the floodplain is the Little Butte Volcanic series, including the tuffs of the Mohawk River Caldera and basalts of the Mt. Tom formations (McClaughry et al., 2010). Miocene-aged granitic intrusions from Late Western Cascade Volcanics are also present in the study area. Small areas (<15 acres) of the Eugene Formation and Eocene/Oligocene-aged basaltic intrusive rocks of the Early Western Cascade Volcanics are also present in the 1% AEP study area (McClaughry et al., 2010). The White

Branch fault zone is a N-S striking normal fault located 13 miles east of Cougar Dam and 17 miles east of Blue River Dam (Personius, 2002d).

### *3.4.1.4.2 Cougar*

Cougar Dam (Figure 3.4-7) lies near the fault-controlled boundary between the Western Cascades and the High Cascade geologic provinces. Important geologic features near the dam include Horse Creek fault, which is about 12 miles east and the major strato-volcano South Sister, which is 20 miles west of the project and has volcanism that is less than 1,000 years old.

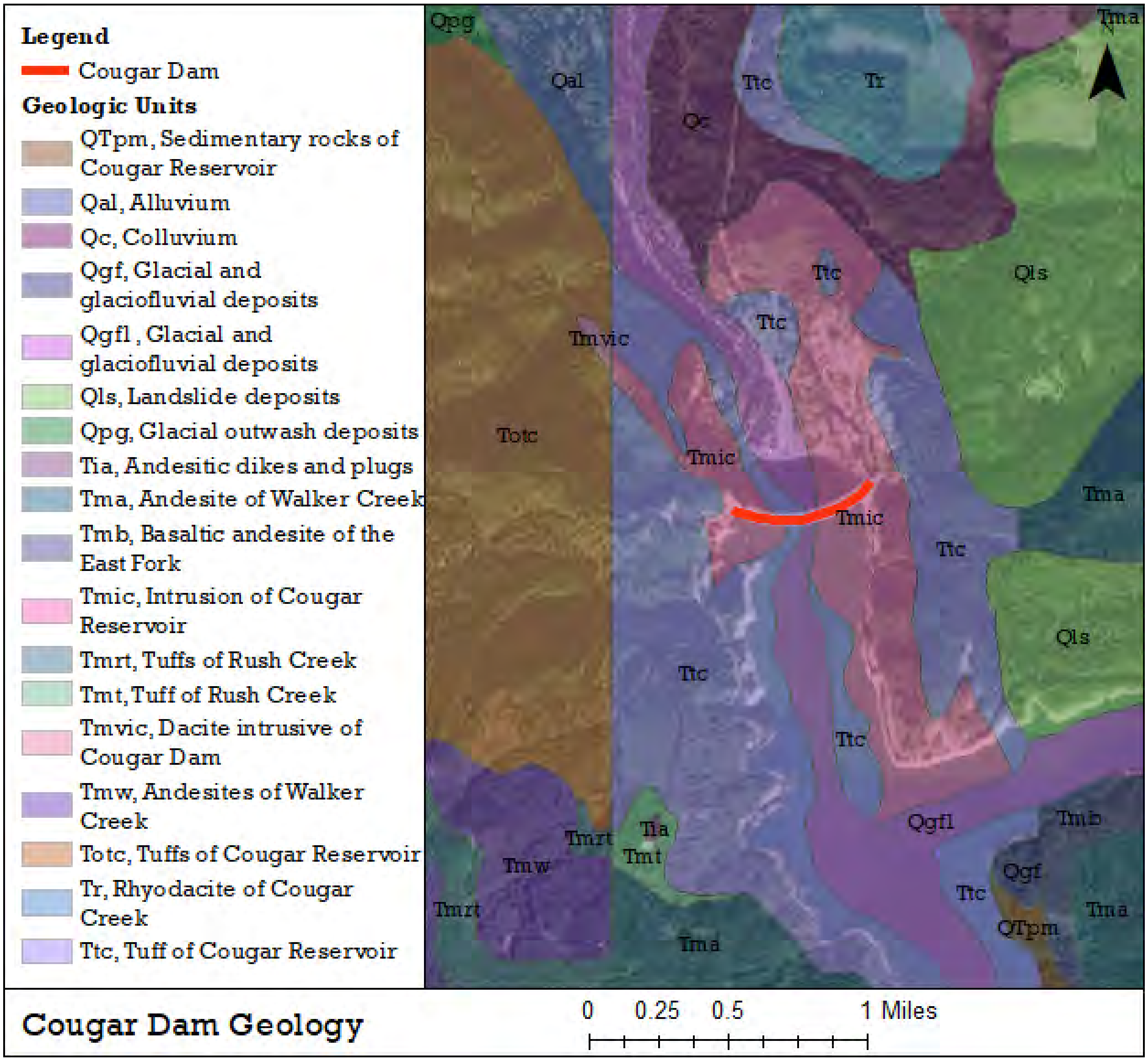



**Figure 3.4-7. Geologic Units in the Vicinity of Cougar Dam**

Source: Priest and Woller, 1983 and Priest et al., 1988

The oldest rock unit in the dam and reservoir area is the series of bedded pyroclastic deposits of the tuff of Cougar Reservoir, which are dacitic tuffs interbedded with ash flows, rhyodacite, andesites, and fine-grained bedded tuffs referred to as “mudstone” in the original design memorandum. The pyroclastics form a massive rock unit which is both faulted and gently folded. The tuffs have been intruded by dikes and other irregular basalt or dacite. The largest intrusion at the site follows the foot print of the dam. The lower contact of the intrusion has been eroded through by the river (USACE, 2017c). A 6 million square foot landslide is located 1.3 miles upstream of the dam and extends into the reservoir (Priest et al., 1988).

##### *3.4.1.4.3 Blue River*

Blue River Dam (Figure 3.4-8) is located in the Western Cascade physiographic subprovince. The reservoir area is dominated by thick, deformed sequences of Tertiary rocks (Oligocene to Miocene); including pyroclastics, lava flows and minor intrusions that resulted from several periods of intense volcanism. The oldest rock units in the area are mudflow (lahar) deposits, massive to bedded fine-to coarse-grained tuffaceous sedimentary rocks, and volcanic conglomerates which exhibit low grade metamorphism. Basaltic dikes intruded the older volcanic deposits. Both the volcanic deposits and dikes are cut by quartz veins associated with the Blue River Mining District hydrothermal system.

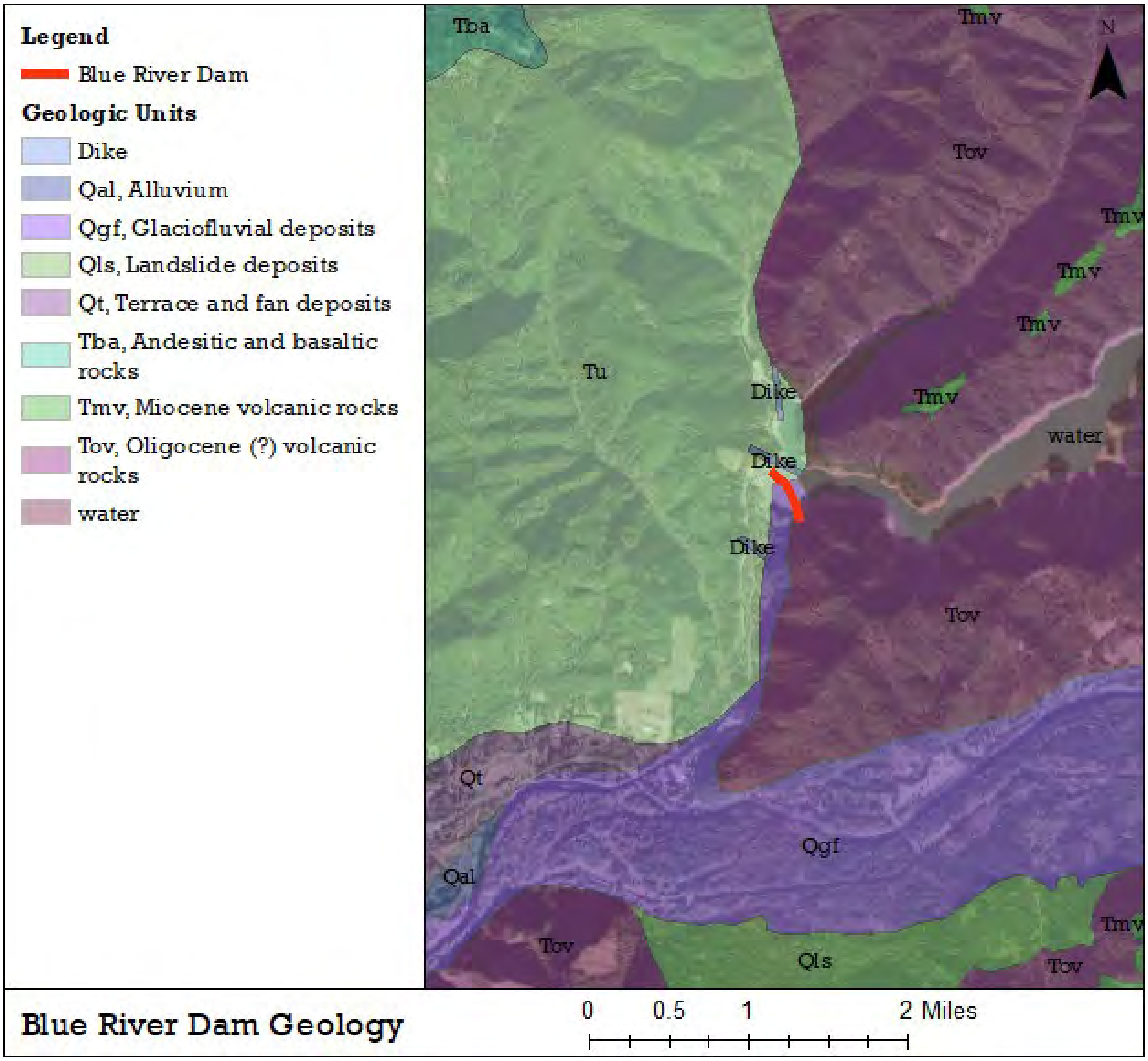



**Figure 3.4-8. Geologic Units in the Vicinity of Blue River Dam**

Source: Brown et al., 1980a and Walker and Duncan, 1989

Ridges adjacent to the dam and reservoir are relatively narrow and have a maximum relief of approximately 2,000 feet. About 40,000 years ago the McKenzie River valley was occupied by an alpine glacier created by the merging of three glaciers from the Three Sisters volcanic mounts. The glacier periodically advanced up the original Blue River drainage, blocked the drainage and formed a glacial lake. In the Quaternary, glacial-influenced stream action, developed narrow canyons with steep side slopes in the main dam area and a wider canyon with steep side slope in the middle and upper reservoir area. Final retreat of the glacier deposited thick sediments in the area of the auxiliary dam resulting in permanent diversion of the river over bedrock near the mouth of Scout Creek, and establishment of current drainage past the area of the main Blue River dam. The foundation rock is predominantly hard and fresh andesite, contact breccia and lapilli tuff. The auxiliary dam foundation is primarily composed of stratified glacial lake and alluvial materials with depths of up to 150 feet (USACE, 2016b).

#### *3.4.1.5 Middle Fork Willamette River*

##### *3.4.1.5.1 Basin Overview*

The Middle Fork Willamette River is located within the Western Cascades physiographic subprovince. Sedimentary deposits make up 70% of the 1% AEP floodplain and 99% of the 0.2% AEP floodplain. The Little Butte Volcanic Series, including the Mohawk River Caldera and Mt. Tom formations, form the majority of bedrock (Peck, 1964; McClaughry et al., 2010). Minor areas (<15 acres) of Early Western Cascade Volcanics, including intrusive rocks and volcanoclastic sediments of the Mehama Formation, are present. Between Lookout Point and Hills Creek Dam the Middle Fork Willamette River traces the path of the Upper Willamette River fault zone, which strikes NW-SE to the east of Hills Creek Reservoir (Personius, 2002h).

##### *3.4.1.5.2 Lookout Point*

The rocks found in the vicinity of Lookout Point Dam (Figure 3.4-9) range in age from Eocene to Miocene, and consist of tilted sediments, pyroclastic beds, and lava flows. The topography is characterized by narrow valleys and sharp ridges that are mostly unrelated to the underlying bedrock structure. Localized folds within the region form short anticlines and synclines. All bedrock in the Western Cascades has experienced low grade metamorphism.

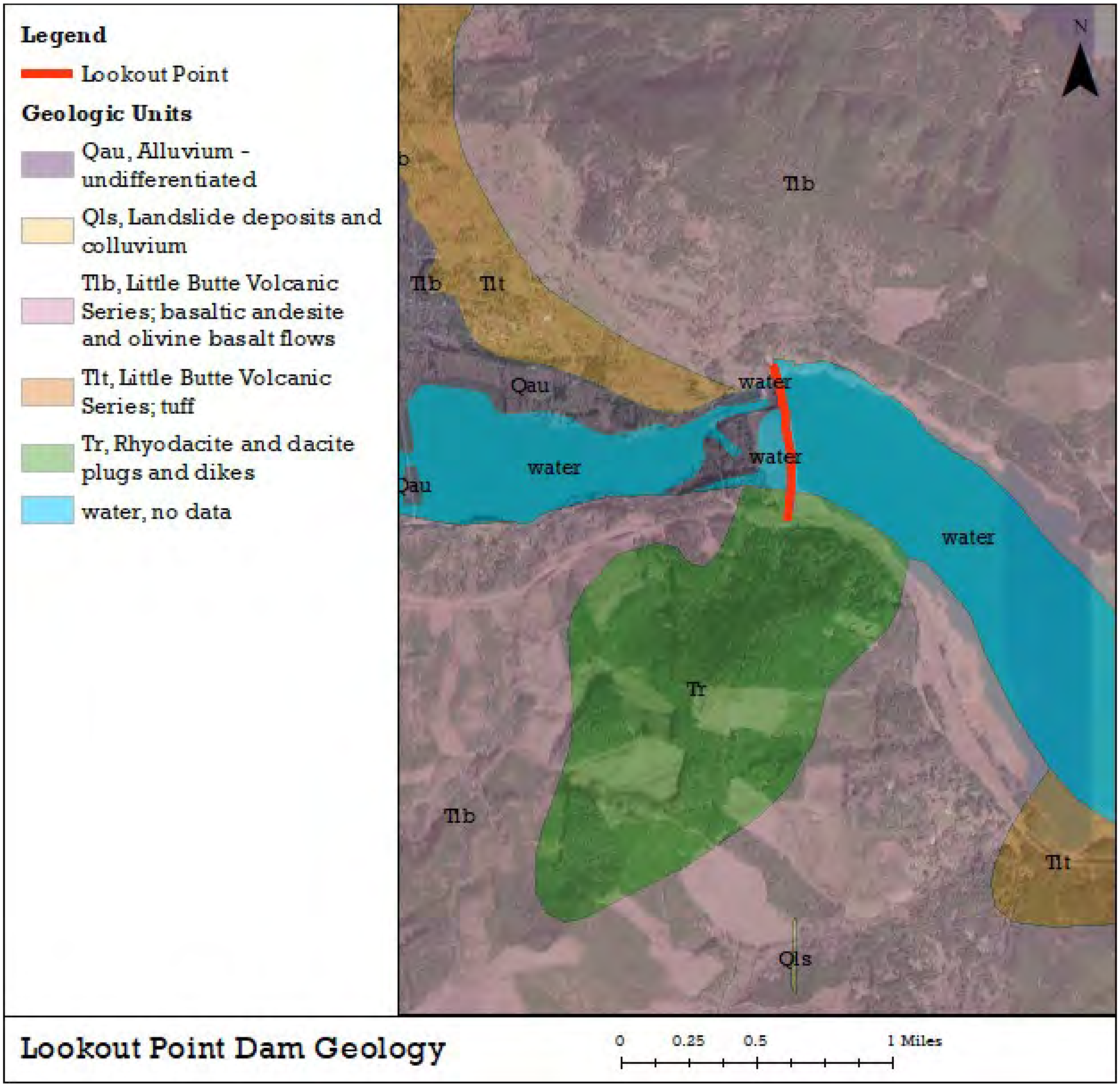



**Figure 3.4-9. Geologic Units in the Vicinity of Lookout Point Dam**

Source: O'Connor et al. and Peck, 1964

Overburden in the valley floor consists of a 10- to 20-foot thick deposit of boulders, cobbles, gravels, sands, silt, and deeply weathered clay talus. The left abutment of the dam is tied into an ancient landslide complex (USACE, 2019d). Two slides extend into the reservoir and are influenced by fluctuations in the Lost Creek Reservoir. The Minnow slide deposit is located on the left bank of Lookout Point Lake, approximately 0.8 to 1.8 miles upstream from the dam and the slide mass extends below the minimum pool (elevation 819 NAVD88). Relocation of the highway and railroad during early construction of Lookout Point Dam reactivated the slide. The Voss slide is 3 miles upstream of the dam on the left bank. The toe is approximately at elevation 859 feet NAVD88 (75 feet below full pool). The Voss slide formed during the first pool drawdown in 1955. Measures were taken to stabilize both slopes, but periodic movements of the slide masses have continued to occur (USACE, 1981). Deposits of clay and talus are prevalent throughout the valley, and large masses were present on both abutments of the dam site.

Volcanic rocks that form the foundation area fall into two main groups, a porphyritic andesite group and a porphyritic augite basalt group. The porphyritic andesite group is the main lithology in the project area. There are three dominate bedrock joint systems at the site, many of which are also open and contain colloidal clay. The main large fault at the dam site cuts diagonally across the stilling basin (USACE, 2019d).

###### *3.4.1.5.3 Hills Creek*

The Hills Creek Project (Figure 3.4-10) is located in the central Western Cascade Range. The dam occupies a steep-sided canyon at the confluence of Hills Creek and the Middle Fork of the Willamette River, where the original valley was about 700 feet wide. Overburden at the dam site is mainly a gravel-cobble-boulder alluvium that increases in depth from the right abutment to the left abutment. The upper 10 to 15 feet of the gravel is mostly unweathered, hard, and unconsolidated. Deeper alluvium contains a high percentage of weathered and compacted gravel that is permeable. Outside the original river channel, the floodplain has a blanket of 3 to 8 feet of silty sand. Overburden on the left abutment includes deeply weathered Lapilli Tuff and shallower landslide deposits (USACE, 2019c). An 18 million square foot landslide is located 0.4 miles SW of the dam (Walker, 2002) and several large landslides are mapped 1 mile east of the dam (Sherrod, 1991 and Brown et al., 1980b). Both landslides extend into the reservoir.

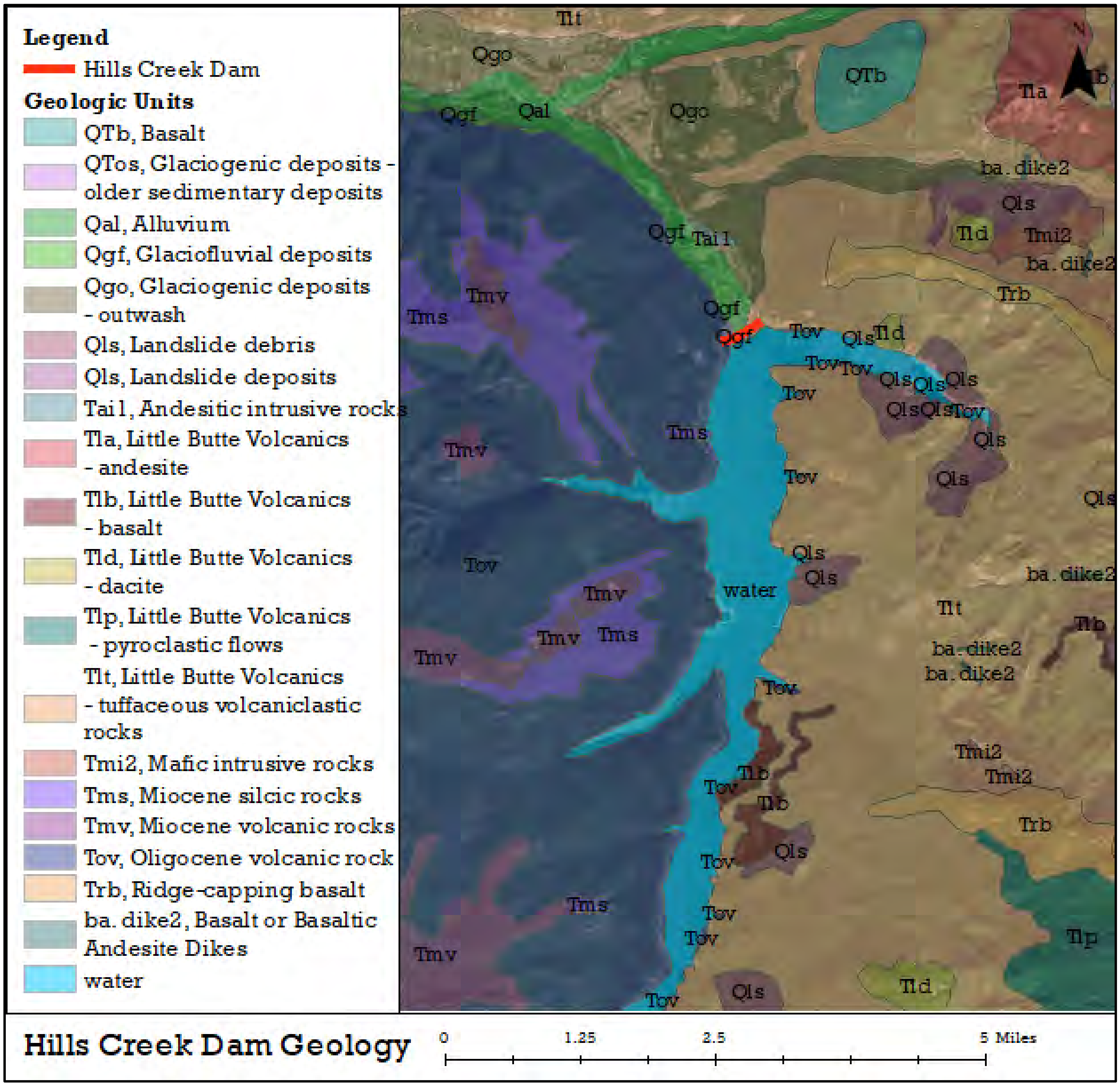



**Figure 3.4-10. Geologic Units in the Vicinity of Hills Creek Dam**

Source: Brown et al., 1980b and Sherrod, 1991

Hills Creek Dam is founded in Oligocene-Miocene-age tuffs of the Little Butte Volcanic Series. The tuffs have been hydrothermally altered, sheared, and displaced by intrusive rocks. Near the dam, intrusive rocks include small localized sills, a massive hornblende andesite intrusion in the left abutment, a large dacite dike downstream of the dam centerline and in the right abutment, and a large diabase dike downstream of the dacite dike.

The Hills Creek Project coincides with the intersection of two major fault zones, the Middle Fork and Hills Creek Faults. The faults are associated with widespread shearing, clay-filled rock joints and fractures, and deep weathering in the project site vicinity. These faults are believed to be inactive based on USGS mapping, and pre-construction geologic mapping provides no evidence of recent fault activity (USACE, 2019c).

*3.4.1.5.4 Dexter*

Most of the overburden in the Dexter Dam (Figure 3.4-11) area is shallow, consisting of loose, sandy gravel containing cobbles and occasional boulders. Cemented gravel and boulders were encountered in the fault-controlled channel beneath the upstream training wall. The base of the right abutment and the west end of the fishway have shallow residual clays and talus (USACE, 2015d). No modern landslides are mapped within the reservoir area (Walker, 2002).

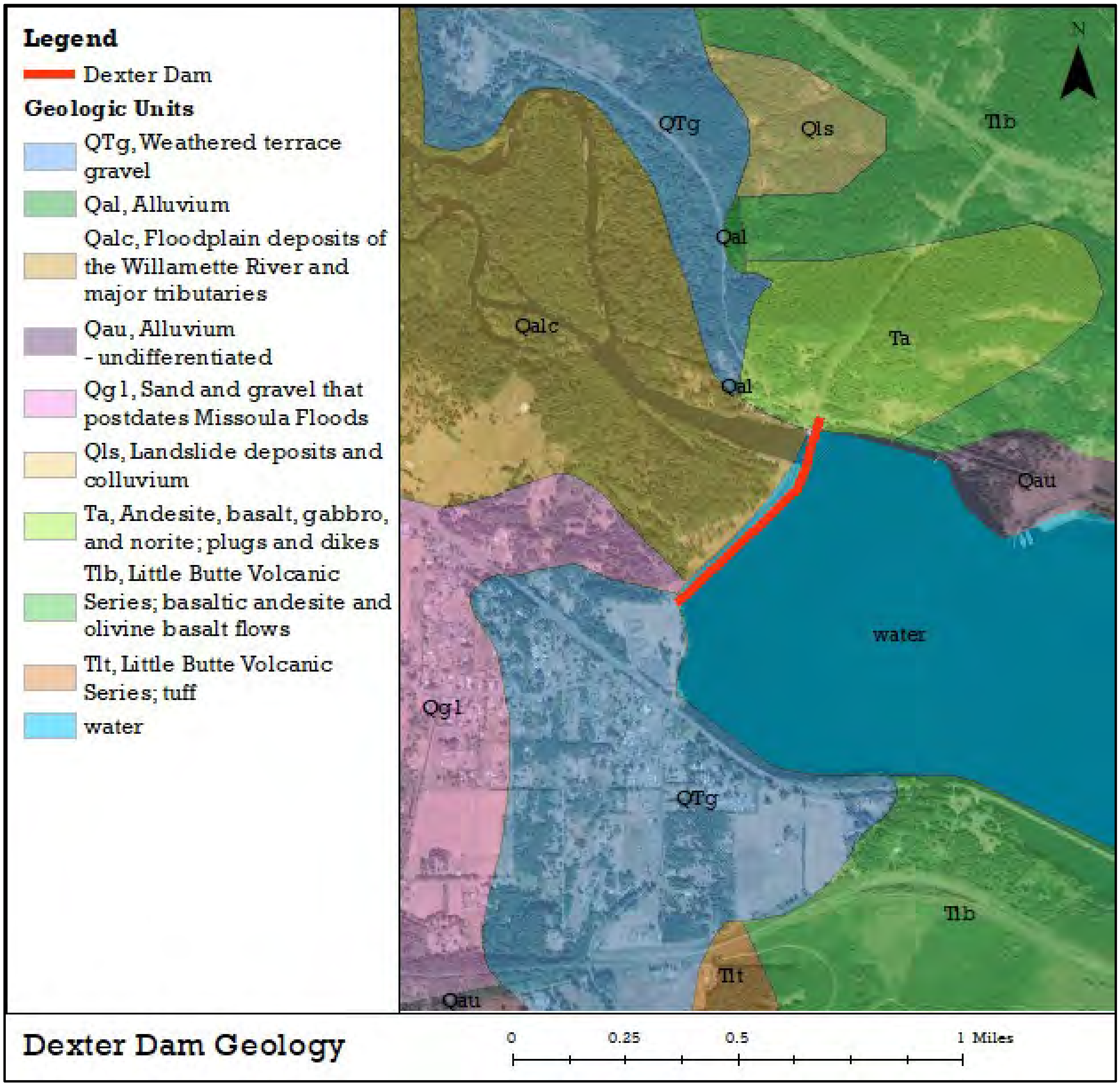



**Figure 3.4-11. Geologic Units in the Vicinity of Dexter Dam**

Source: O'Connor et al., 2001 and Peck, 1964)

Bedrock in the concrete structure area consists of a series of pyroclastic tuffs and tuff breccia that have been intruded by dense, hard basalt. The surface of the foundation is for the most part a remnant of a basalt flow or flows which has been eroded deeply enough in places to expose the underlying pyroclastics. There are numerous faults in the embankment foundation, some of which are responsible for steep to near vertical slopes in the foundation surface. The most prominent and extensive fault in the concrete portion of the dam is the Powerhouse Fault, which follows the contact of the pyroclastics and the main body of intrusive basalt. This fault movement was probably produced in the late stages of intrusion after solidification of the magma. Foundation rock beneath the embankment area is a composite series of pyroclastic rocks and basalt flows with occasional intruding fingers of basalt. One important fault that was uncovered during construction was a fault zone that transects the embankment dam. The Foundation Report states that indicators of frictional movement between rocks along the two sides of a fault were observed within the alluvial gravels overlying bedrock. USACE initiated a geologic reconnaissance of this fault/lineament in the early 1980s which suggests that the last activity was Early Pleistocene (>100,000 years). There is no confirmed activity on this geologic fault in the last 10,000 years. (USACE, 2015d).

##### *3.4.1.5.5 Fall Creek*

The topography within the Fall Creek Drainage Basin is irregular with much variation observed in slope steepness around the lake. Fall Creek Dam (Figure 3.4-12) is located along the lowermost foothills of the Cascade Range and discharges to the southern extent of the Willamette Valley. The valley slopes extend approximately 500 feet to nearly 1,400 feet above the lake elevation.

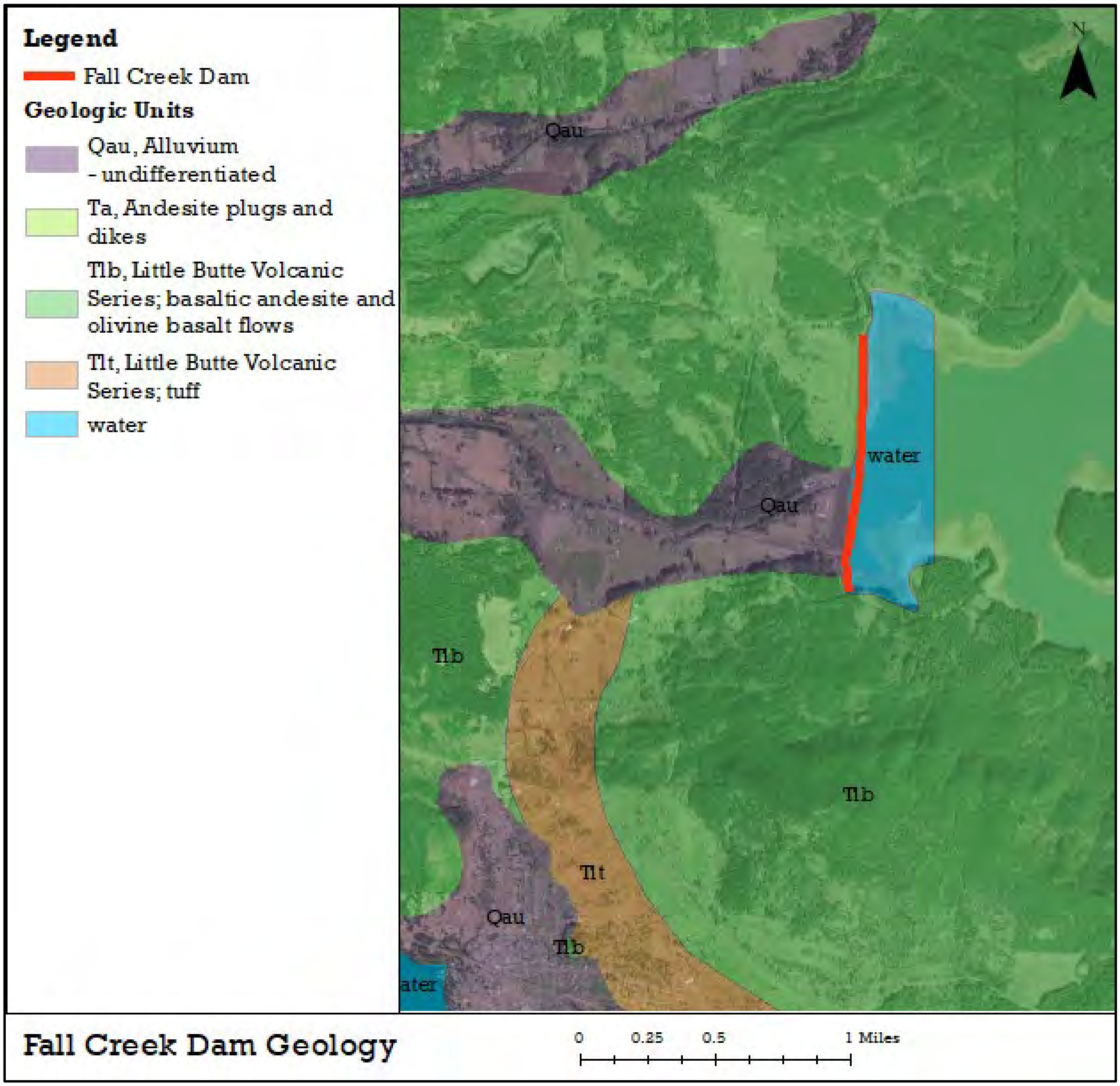



**Figure 3.4-12. Geologic Units in the Vicinity of Fall Creek Dam**

Source: O'Connor et al., 2001 and Peck, 1964

Historically, downcutting of the Fall Creek and Winberry Creek valleys was periodically interrupted by valley deposition and infilling, as indicated by deeply weathered terrace deposits along the valley walls. Numerous landslide deposits are present along the slopes around Fall Creek Lake in deep overburden and/or intensively weathered rocks (USACE, 2014b), but no modern landslides are mapped within the reservoir area (Walker, 2002). The right abutment is located on an old alluvium-filled river channel. The residual soil consists of sandy silty clay and silty gravel. The decomposed terrace gravels consist of dense, silty, gravelly sand. Left abutment overburden was mostly shallow residual silty soil and slopewash between scattered rock outcrops, with some small local talus deposits. An old gravel terrace is located upstream on the left abutment.

The foundation material in the area of Fall Creek Dam consists of lava flows, intrusive rock masses, fragmental pyroclastic materials, and the lowest member of the stratigraphic sequence is volcanic derived sandstone. The pyroclastic- and volcanic-derived sandstone materials are the dominate rock types. In the dam foundation area, the resistant andesite rock materials are intrusive in origin and form the blufflike abutments, especially on the right abutment.

An intrusive contact zone separates andesite that extends from the intake of the regulating outlet to the dam axis and sandstone that extends to the downstream end of the discharge channel. The dam foundation alignment generally follows this contact. Major rock fractures and joint sets generally trend approximately NE and NW with minor fractures and joint sets trending north and east. (USACE, 2014b).

#### *3.4.1.6 Middle Main Stem Willamette River*

##### *3.4.1.6.1 Basin Overview*

The study area for the Middle Main Stem Willamette River is within western half of the Puget Trough. More than 99% of the study area is unconsolidated deposits and bedrock is composed primarily of the Miocene-aged Columbia River Basalt Group, including the Grande Ronde and Wanapum formations, and Eocene-aged marine sedimentary rocks of the Keasey Formation (O'Connor et al., 2001; Yeats et al., 1996). Major faults that intersect the study area include the Salem-Eola homocline (Personius, 2002b), Newberg fault (Personius, 2002c), Canby-Molalla fault (Personius, 2002e), and Bolton fault (Personius, 2002a).

#### *3.4.1.7 North Santiam Subbasin*

##### *3.4.1.7.1 Basin Overview*

In the North Santiam subbasin unconsolidated sediments cover 99% of the 1% AEP and 100% of the 0.2% AEP. The majority of the surficial bedrock in the area is from the Little Butte Volcanics and the intermediate rocks of the Late Western Cascade Volcanics, including the andesite volcanic rocks of the Sardine Formation. A small area (<16 acres for each formation) of the 1% AEP study area contains the Columbia River Basalt Group, the Eugene Formation, and the Keasey Formation. The Salem-Eola Hills homocline is mapped at the downstream end of the basin (Personius, 2002b).

##### *3.4.1.7.2 Detroit*

Overburden at Detroit Dam (Figure 3.4-13) consisted of 0 to 70 feet of talus, river alluvium, glacial debris, and remnants of old cemented terrace river gravels (USACE, 2016c). Many 1-10 million square foot landslides are mapped extending into the water along the right bank of the reservoir about 4 miles upstream of the dam (Calhoun et al, 2020). These areas are shown as active landslides showing active movement since completion of the reservoir in the Detroit DM 4 (USACE, 1983). Detroit Dam is founded on Hall Diorite near the roof and northern margin of a 2 to 3 square mile pluton. It is intruded into the Lower Member of the Sardine volcanic country rock, which is composed of stratified tuffs, tuff breccias, andesite flows, and volcanic sedimentary rocks. In order of abundance, bedrock at the dam consists of the following: andesite breccia, diorite, aplite, andesite porphyry, hydrothermally altered phases of these rocks, and vein material composed of crushed vein matter, quartz and traces of hematite, lead, and zinc minerals. The andesite breccia is a hard and brittle rock mass that occurs along the northwestern and western margin of the intrusion and has been altered.

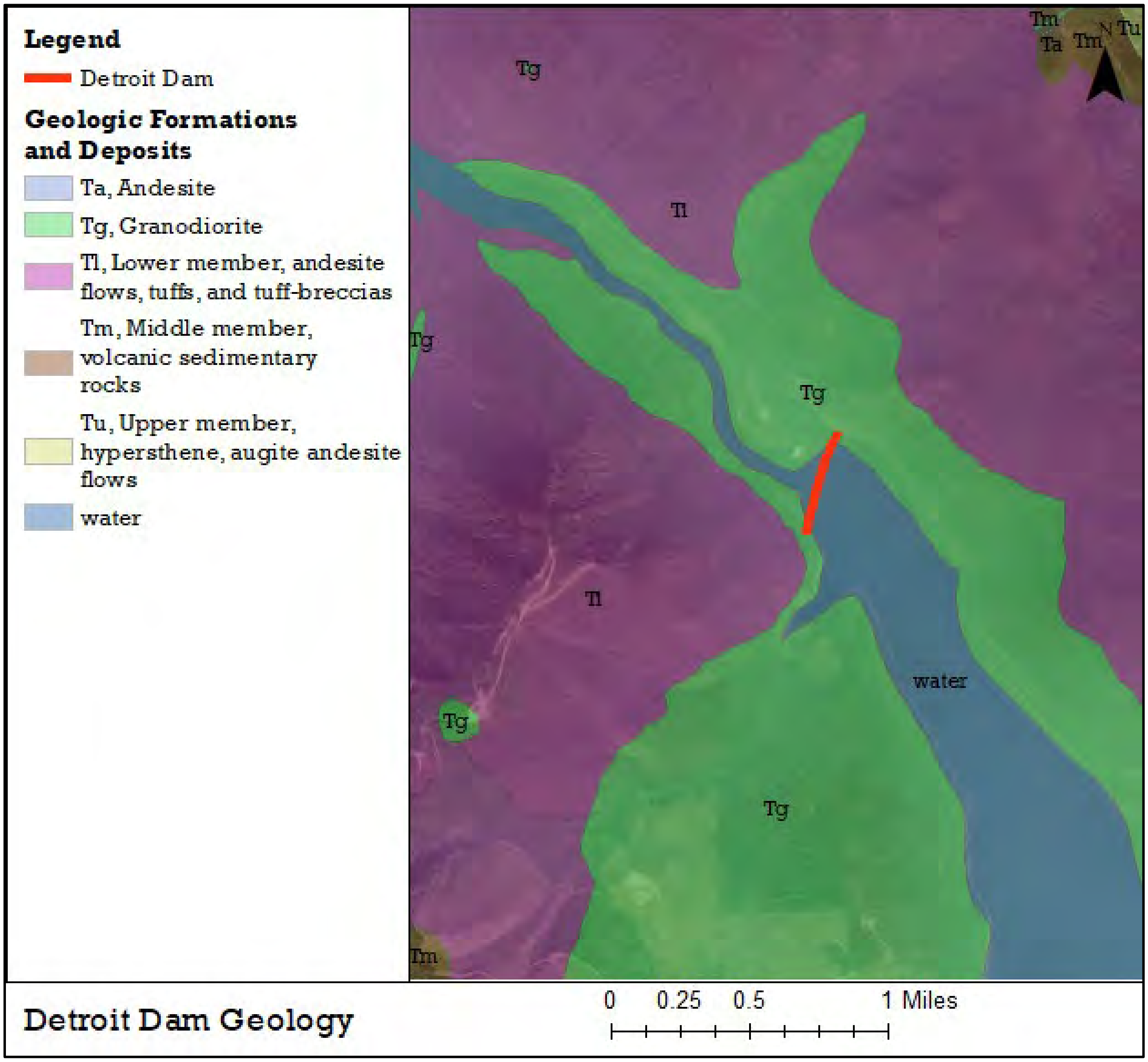



**Figure 3.4-13. Geologic Units in the Vicinity of Detroit Dam**

Source: Pungrassami, 1969

Primary direction of faults, fissures, shears and joints in the foundation strike NW, nearly parallel to the dikes of andesite porphyry and the Hall Diorite. The larger northwest striking shears have been mineralized and presently consist of a few inches to nearly 5 feet of shattered rock in a hard matrix of quartz and epidote. Northeast striking faults and shears exposed in the foundation were generally tight and fresh. Joints higher up on the abutments and above the dam typically were deeply weathered to clay (USACE, 2016c).

### *3.4.1.7.3 Big Cliff*

Big Cliff Dam (Figure 3.4-14) is in located in a steep V-shaped canyon, the sides of which reach heights from 1,500 to 2,500 feet above the stream channel. The channel is little more than 50 feet wide, and there is no floodplain. The left abutment is a vertical cliff from which the site derives its name. The entire site is underlain by massive, sound, andesite lava flows, tuffs, and lapilli tuffs. The tuffs are overlain by a dense porphyritic andesite flow that reaches a maximum thickness of 200 feet, strikes northwesterly, and dips 20 degrees southwest. The lower 50 feet of this flow is highly brecciated.

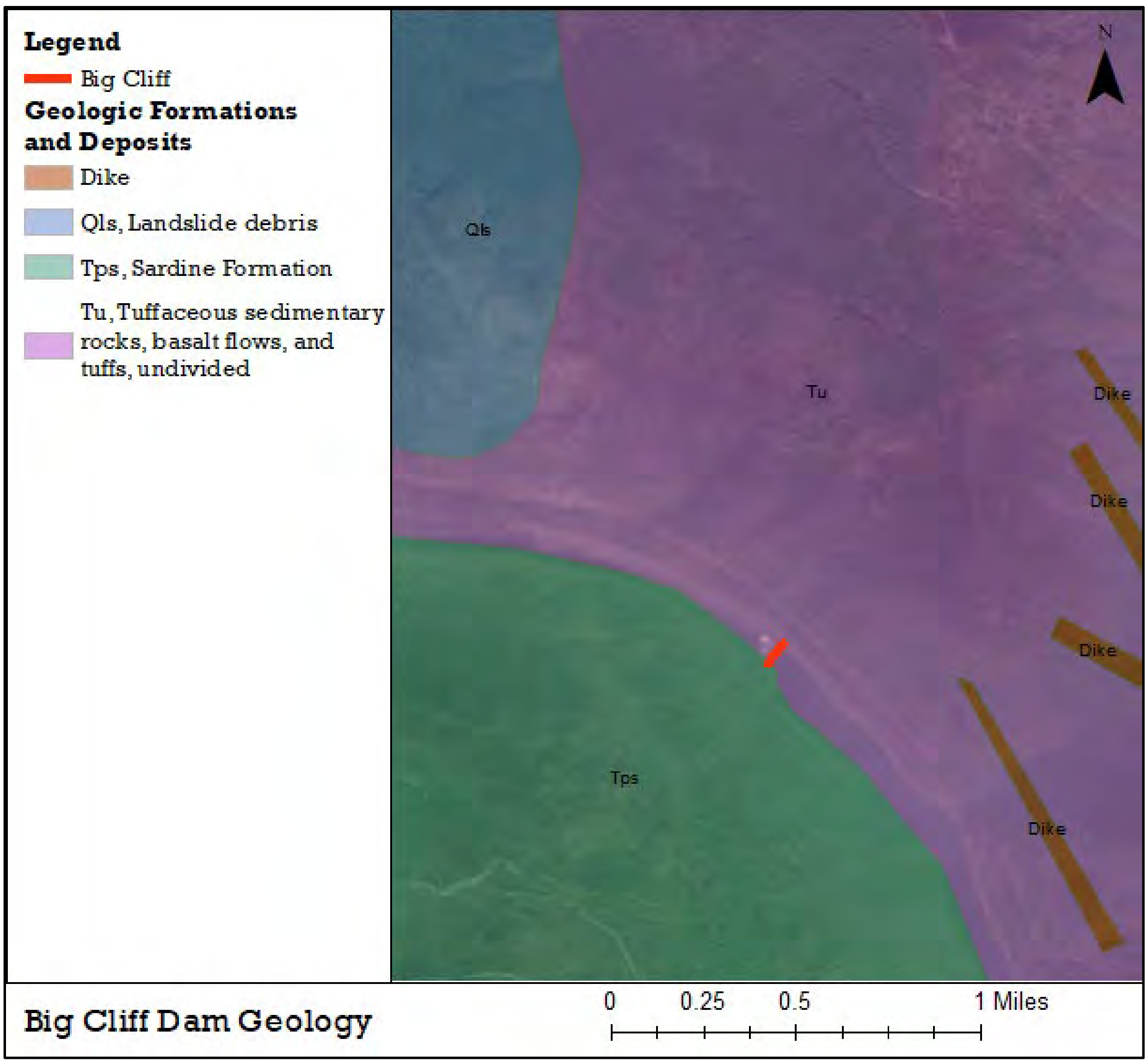



**Figure 3.4-14. Geologic Units in the Vicinity of Big Cliff Dam**

Source: Beaulieu, 1947

### *3.4.1.8 South Santiam Subbasin*

#### *3.4.1.8.1 Basin Overview*

Unconsolidated deposits in the South Santiam River study area make up 73% of the 1% AEP floodplain and 100% of the 0.2% AEP floodplain. Little Butte Volcanics, including the Mt. Tom and Scorpion Mountain Formations form the majority of bedrock in the area, with a lesser surface area of the Mehama Formation. Miocene/Pliocene age terrestrial sedimentary rocks of the Early High Cascade Volcanics and Grande Ronde Basalt are also present (Beaulieu, 1971; McClaughry et al., 2010; Yeats et al., 1996). There are no major quaternary faults or folds recorded in the study area.

#### *3.4.1.8.2 Foster*

Foster Dam (Figure 3.4-15) is located in the deeply eroded valley that was formed by the confluence of the Middle Santiam and South Santiam Rivers. Slopes around Foster Lake were formed by rapid down-cutting into alternating layers of strong and weak volcanic rocks. Oversteepened lower valley slopes have a potential for slides, but most slope failures are limited to local overburden accumulations. Below the juncture of the two rivers the valley is much wider and is marked by a sequence of five well-developed, contiguous alluvial terraces consisting of discontinuous layers, lenses, and mixtures of gravel and sand sized clasts and low plasticity silt. Valley overburden is primarily deposits of poorly graded, clean gravels near the surface and well graded silty sandy gravel at depths below 15 ft.

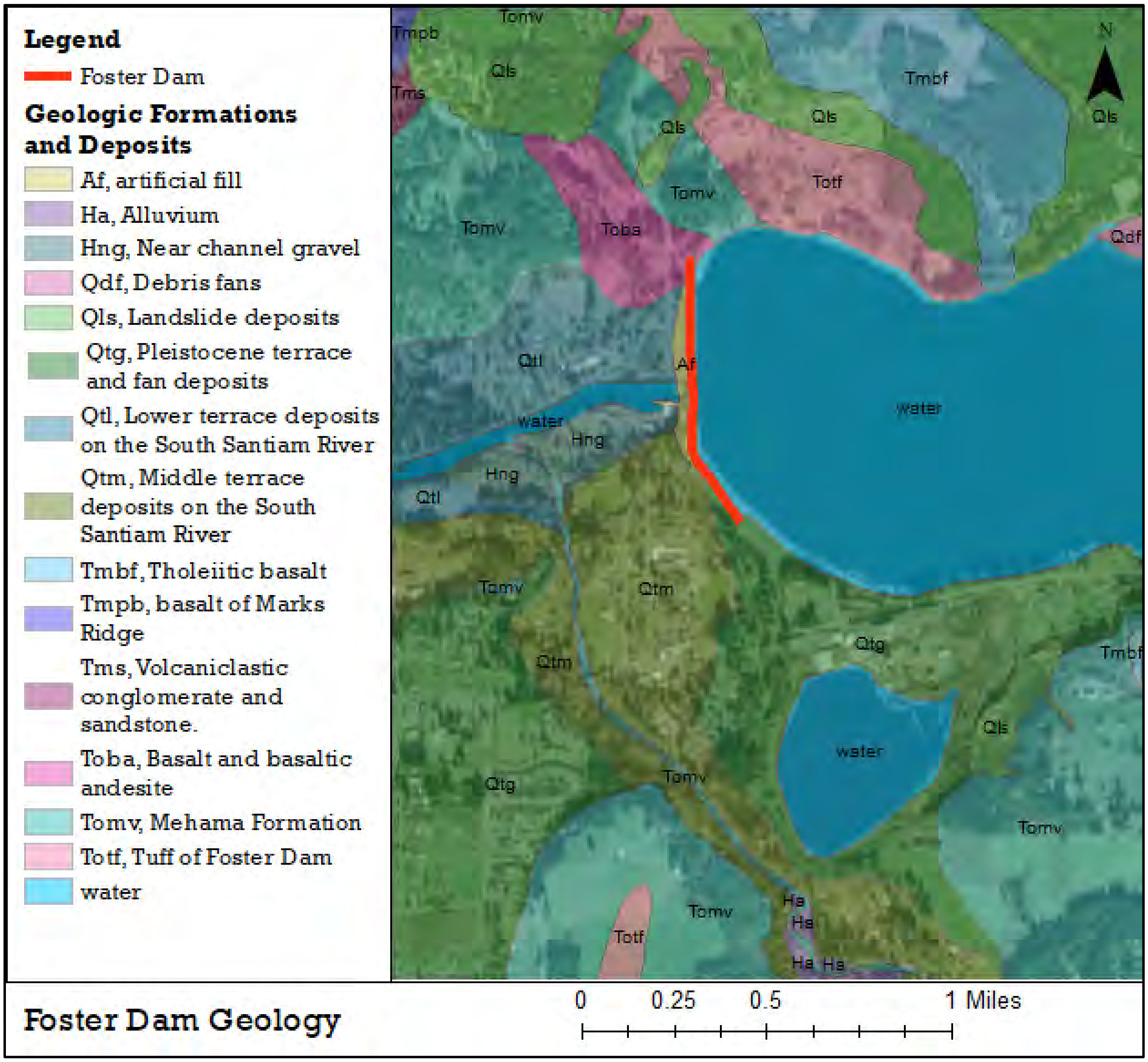



**Figure 3.4-15. Geologic Units in the Vicinity of Foster Dam**

Source: McClaughry et al., 2010

The Mehama Formation is exposed in outcrops along the right dam embankment and is capped by basaltic rock units. It is part of the Little Butte Volcanics and consists of undifferentiated sedimentary rocks and tuffs. The sedimentary rocks are mainly indurated, non-marine volcaniclastic conglomerate, breccias, sandstone, and mudstone. Bedrock in the dam foundation area consists of two major rock units and three subunits. The major rock units are the Wiley Creek Tuff and the Foster Basalt. Subunits comprising the Wiley Creek Tuff within the dam site area are the upper Ashy Tuff Member, the middle Sandy Tuff Member, and the lower Lapilli Tuff Member. Stratigraphic boundaries between these members are not always distinct and individual members have considerable lateral variation.

Foster Dam is situated between two northeast trending tertiary aged geologic structures: (1) Foster Lake Anticline, and (2) an unnamed syncline. Folded strata in the area are cut by a series of conjugate northwest- and northeast-trending normal faults and several northwest-trending strike-slip faults. Two other normal faults have been mapped near the site: an east-northeast trending fault approximately 0.5 miles southeast of the site and a north-northeast trending fault approximately 0.7 miles east of the site associated with Hogback Ridge. Both these faults are downdropped to the northwest, cut Oligocene- to Miocene-aged rock units, and have been mapped trending through Foster Lake (USACE, 2015f).

##### *3.4.1.8.3 Green Peter*

The USGS interprets geologic bedrock at the Green Peter Dam site as predominantly sedimentary (Figure 3.4-16). However, detailed geological investigations at the dam site show bedrock is predominantly volcanic andesite and basaltic lava flows; Tertiary Andesite Lavas approximately 17-25 million years old (labeled as Ta3) would be a more appropriate characterization (Figure 3.4-17). Green Peter Dam is most likely located on the flanks of an old shield volcano where the individual lava flows may be separated by volcanic ash/cinders and occasionally by bedded volcanic sediments (Figure 3.4-18).

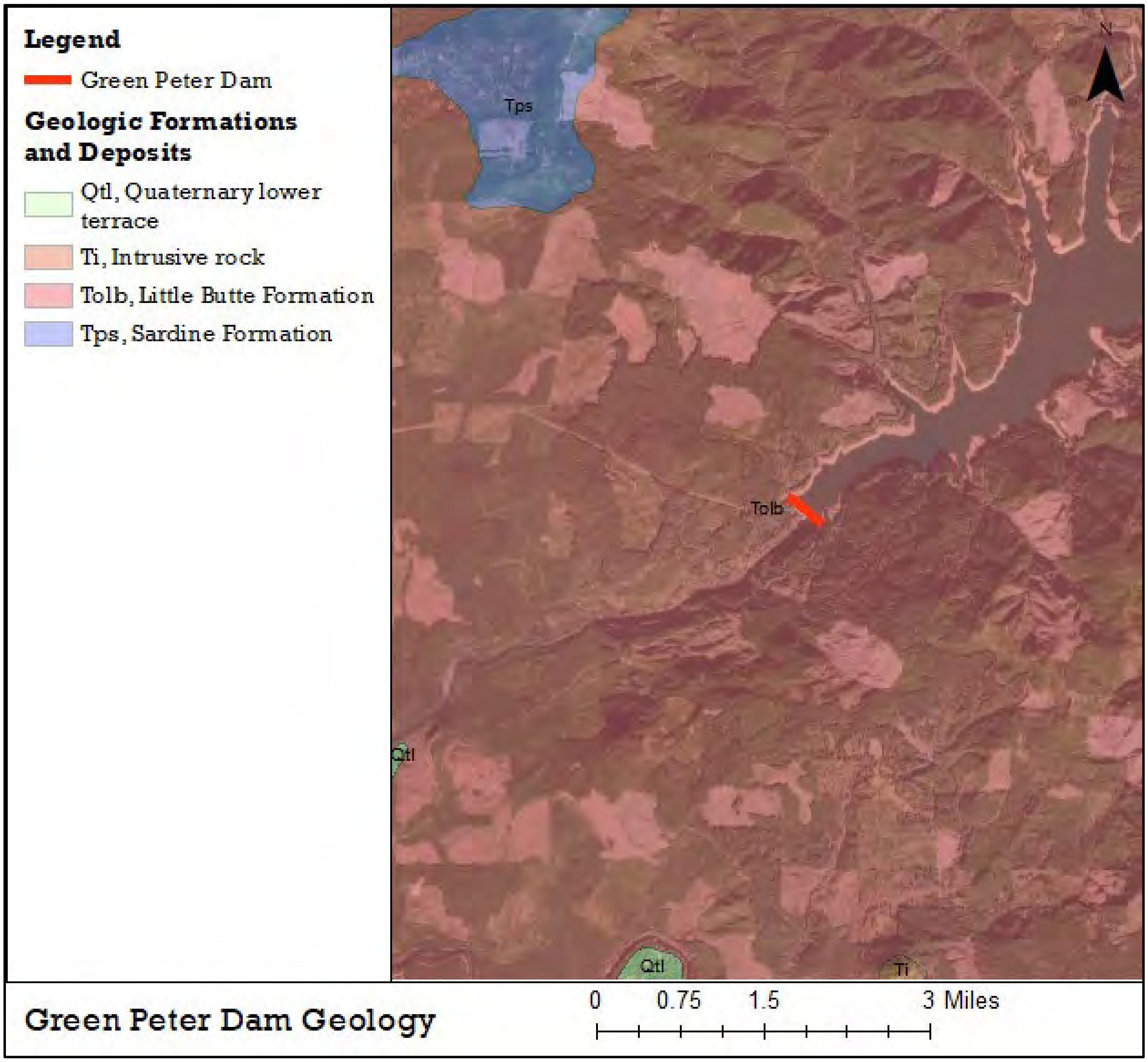
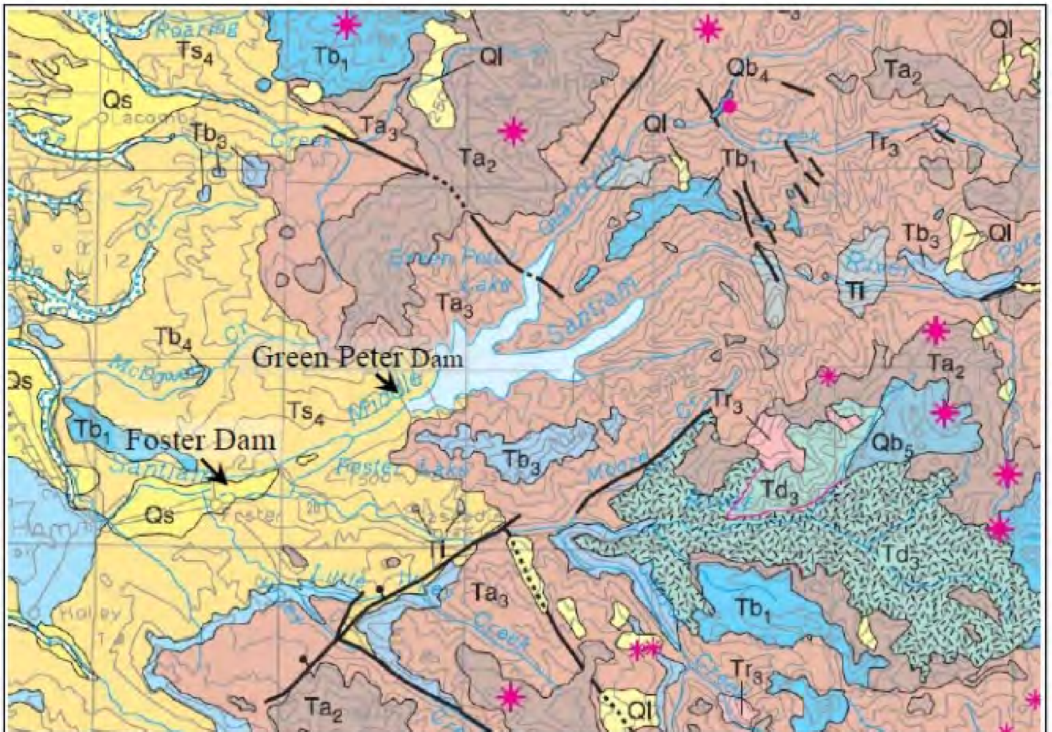



**Figure 3.4-16. Geologic Units in the Vicinity of Green Peter Dam**

Source: Beaulieu, 1947




Legend:

| Geologic Epic | | Lithology | | Age (million years) | |
|---|---|---|---|---|---|
| Q | Quaternary | l | Landslide | 1 | 2 to 7 |
| T | Tertiary | s | Sediment | 2 | 7 to 17 |
| | | a | Andesite Lavas | 3 | 17 to 25 |
| | | b | Basalt Lavas | 4 | 25 to 35 |
| | | d | Dacite Lavas | 5 | 35 to 45 |
| | | r | Rhyolite Lavas | | |

Example: $Ta_3$ = Tertiary - Andesite Lava Flows - 17 to 25 million years old

**Figure 3.4-17. USACE Interpretation of the Regional Geologic Map around Green Peter and Foster Dams**

USACE, 2015d

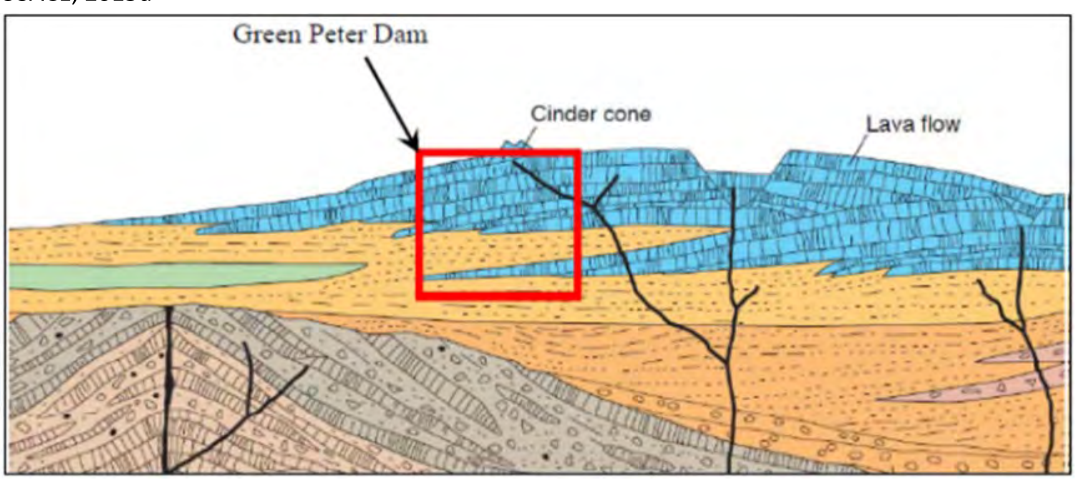



**Figure 3.4-18. Cross Section of the USACE Interpretation of the Regional Geologic Map around Green Peter and Foster Dams**

USACE, 2015d

The dam foundation is constructed in a relatively narrow portion of the Middle Santiam River where the river is downcutting through a layered series of 15 lava flows and 5 interbeds of pyroclastics. The geology through this stretch consists of extensive terrain of ancient landslides. Numerous smaller historic landslides have occurred downstream along the Middle Santiam River. Overburden at the site consists of 7 to 53 feet of soil underlain by up to 24 feet of decomposed rock on both abutments. The dam abuts into rock on both abutments. However, there remains a remnant of an ancient buried river channel further to the east on the left abutment that is separated from the dam by a bedrock high (USACE, 2015d). A 2.5 million square foot landslide is mapped directly upstream of the dam on the left abatement, but it is difficult to tell from the available information whether it is in contact with the reservoir (Beaulieu, 1974). During construction of Green Peter the flood of December 1963 - January 1964 caried landslide debris down Big Alder Creek into the right abutment working area (USACE, 1969). The main body of the Big Alder Creek slide is mapped on the right embankment hillslope above the reservoir (Beaulieu, 1974).

#### ***3.4.1.9 Upper Main Stem Willamette River***

##### *3.4.1.9.1 Basin Overview*

The Upper Willamette Subbasin spans all three physiographic sections within the Willamette Valley, so bedrock includes marine Coast Range formations, volcanics of the Western Cascades, and large amounts of unconsolidated deposits, which make up 99.7% of both the 1% and 0.2% AEP floodplains in the study area. Coast Range formations include Eocene-aged marine pillow lavas and sediments of the Siletz River Volcanics, turbidite-derived sedimentary rocks of the Tyee Formation, deltaic sandstones of the Spencer Formation, slope mudstone of the Yamhill Formation, continental shelf sandstone of the Eugene Formation, and Eocene- to Oligocene-aged intermediate intrusions of the Coastal Intrusives Group. Early Western Cascade Volcanics within the study area include mafic intrusions, the Mehama Formation, and the Eocene-aged, welded, Tuff of Bond Creek (McClaughry et al., 2010; Yeats et al., 1996). The Owl Creek fault (Personius, 2002f) strikes N-S paralleling the Willamette River and the Corvallis fault zone strikes NE-SW along the western edge of the study area (Personius, 2002g).

### 3.4.2 **Environmental Consequences**

#### ***3.4.2.1 Methodology***

This evaluation is based on review of existing geologic reports and qualitative geologic and engineering judgement using known mechanisms of geologic hazards. No new geotechnical or seismic models were developed as part of the analysis. Sediment transport associated with the revetments measure and small-scale impacts to sediment transport from mechanisms like slumping and erosion is discussed in Section 3.3 – River Mechanics and Geomorphology. Environmental consequence impacts are identified for the activation of landslides due to deep drawdown and removal of geologic material metrics based on thresholds of relative change (Alternative versus NAA) normalized to four levels (Negligible, Minor, Moderate, and Major).

Geologic processes develop over the span of hundreds to millions of years and the influence of operational changes from a dam to the geologic environment is limited. Only environmental consequences that are likely to cause impacts in the near future were considered in this analysis.

#### *3.4.2.1.1 Activation of Landslides Due to Deep Drawdown*

The activation of landslides due to deep drawdown metric indicates the potential for the reduction of the minimum pool elevation to induce landslides for the following measures: deeper fall reservoir drawdowns for fish passage (#40), augment instream flows by using the power pool (#304), augment instream flows by using the inactive pool (#718), and spring reservoir drawdown for downstream fish passage (#720). Currently withdrawal from the inactive pool is rare and only occurs during times of extreme drought or during special operations.

When a reservoir level drops more quickly than the pore water can drain, the water remaining in the unconsolidated bank material that was at a steady state with the reservoir water has pore pressures that exceed atmospheric pressure. If water cannot drain quickly enough for pore water pressures to dissipate, for example if the slope is composed of clay or silt, the slope experiences higher shear stress and there is the potential for slope instability (Wieczorek, 1996). For example, it was observed during the intentional breach of Condit Dam that exposure of unvegetated slopes during the full drawdown of the reservoir resulted in slumping of the bank that progressed upstream and caused slope failures through the lower ~2100 feet of the reservoir (Wilcox, et al., 2014). There is no proposed change to reservoir drawdown rates that would result in drawdowns as rapid as those experienced at Condit Dam, but the progressive failure of exposed un-vegetated shoreline soils that were previously saturated and are prone to erosion and slumping due to extended reservoir drawdown is of concern.

Additionally, there is concern that small scale erosion and slumping of the newly exposed, unvegetated reservoir slopes that is assessed in Section 3.3 could progressively destabilize areas of existing weakness, like historic landslides. The presence of historic landslides is used as a proxy for the potential of slope failure in this assessment. Most types of landslide have a high probability of reoccurring in areas that have experienced previous landslides (Highland and Bobrowsky, 2008).

Small scale landslides (defined in this assessment as the resulting landslide body having a surface area extent of <100,000 square feet) are commonly caused by heavy rains and are part of the normal geotechnical regime. It would be difficult to detect whether a small-scale landslide is induced by the change in reservoir operation or other natural processes. Moderate (100,000 square feet - 10,000,000 square feet) and large (>10,000,000 square feet) landslides are likely to have a greater impact on dam safety and critical infrastructure than small scale landslide. For this reason, the presence of moderate and large landslides was used to indicate a higher likelihood of environmental consequences occurring. Typically, the most dangerous time for reservoir slope failure is at initial filling and the period of refilling after the first two cycles of rapid drawdown because the increase in water pressure within the slope increases poor water pressure and reduces the effective strength of the reservoir slope, allowing slopes that are already vulnerable to movement to fail (Wieczorek, 1996). Landslides that experienced movement during or since initial filling are considered more likely to have environmental consequences than historic landslides that have not shown indications of failure vulnerability in this assessment.

Over the lifetime of the Willamette Valley projects there has not been a case of a deep drawdown causing initiation of an existing landslide resulting in a moderate or large earth movement. Cougar was drawn down to below elevation 1510 feet NAVD88 without incident between December 20, 2012 and January 12, 2013 (USACE, 2013b), which is 4 feet above the minimum drawdown elevation recommended under Alternative 2A. Fall Creek was drawn down to the elevation of the original river channel (680 feet NAVD88) during a 2015 fish operation without incident (USACE, 2016d). Although the Willamette Valley projects do not have a history of poor performance during drawdown the presence of landslides that extend into the reservoir mean that the potential for failure cannot be eliminated.

There are four levels of change when comparing the No Action Alternative (NAA) to the others (Table 3.4-1):

**Table 3.4-1. Evaluation Criteria for Activation of Landslides Due to Deep Drawdown**

| Effect Scale | Criteria |
|---|---|
| **None/negligible** | No or only small landslides are mapped in contact with the reservoir pool or the surface exposure metric calculated in Section 3.3 has an effect rating of “none/negligible” or “minor.” |
| **Minor** | The surface exposure metric calculated in Section 3.3 has a “major” effect rating and landslides of moderate or large surface area mapped in connection with the reservoir that do not have a history of movement since the beginning of reservoir operation and engineering judgement indicates that the probability of slope failure due to deep drawdown cannot be eliminated. |
| **Moderate** | The surface exposure metric calculated in Section 3.3 has a “major” effect rating and landslides of moderate or large surface area are mapped in connection with the reservoir that have a history of movement since the beginning of reservoir operation. And no site-specific study that indicates failure is likely to occur due to deep drawdown is available, but, based on engineering judgement, initiation of landslides by deep drawdown cannot be ruled out. |
| **Major** | The surface exposure metric calculated in Section 3.3 has a “major” effect rating and landslides of moderate or large surface area mapped in connection with the reservoir that have a history of movement since |

| Effect Scale | Criteria |
|---|---|
| | the beginning of reservoir operation. And a site-specific study has shown that the reduction in minimum pool elevation is likely to induce failure of the slope. |

*3.4.2.1.2 Removal of Geologic Material*

Construction of water temperature control towers (#105) and structural downstream fish passages (#392) may necessitate some permanent removal of a non-negligible volume (more than 12 cubic yards) of sediment and bedrock for construction of the temperature control tower foundation and outlets.

There are four levels of change when comparing the NAA to the others (Table 3.4-2):

**Table 3.4-2. Evaluation Criteria for Potential Effects for Removal of Geologic Material**

| Effect Scale | Criteria |
|---|---|
| **None/negligible** | No measures would result in removal of geologic materials. |
| **Minor** | Geologic materials would be removed from the dam site or reservoir as the result of a measure, but these changes would be small and localized. |
| **Moderate** | Geologic materials would be removed from the dam site or reservoir as the result of a measure at a scale that will be measurable and have either localized or regional-scale adverse effects/benefits. |
| **Major** | Geologic materials will be removed from the dam site or reservoir as the result of a measure at a scale that would have substantial consequences on a local or regional level. |

*3.4.2.1.3 Construction*

The Draft PEIS will discuss general, qualitative effects from construction at the programmatic level. Site-specific project details for each construction measure will be determined during the implementation phase. Subsequent tiered NEPA documents would discuss detailed site-specific effects during the implementation phase.

Direct effects from construction on geology and soils include local removal of geologic materials permanently due to excavation and temporally due to dredging. Drawdowns to construct water temperature control towers at Detroit, Lookout Point, Green Peter, and Hills Creek and a long drawdown at Cougar to construct the outlet works for the routine use of the diversion tunnel. Indirect effects from the drawdowns include the potential for slope stability issues from excess pore pressure if the initial drawdown is too rapid and increased shoreline exposure that could allow small scale slope stability issues and erosion to synergistically oversteepen slopes, which could lead to further slope instability issues during post-construction refilling. It is also possible for removal of materials during excavation and dredging to oversteepen the toe of an existing plain of weakness, indirectly leading to failure, but this is usually mitigated by good geotechnical design.

### *3.4.2.2 No Action Alternative*

#### *3.4.2.2.1 Santiam Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Under normal operational conditions the Detroit and Green Peter reservoirs do not go below the minimum conservation pool even in the driest years. Big Cliff and Foster primarily reregulate Detroit and Green Peter during conservation season, smoothing power peaking flow from the upstream dam, and therefore follow the rule curve very closely in all years under the NAA. Large and moderate sized historic landslides are present at Detroit Dam and large landslides that have experienced small-scale movement, causing road maintenance problems, since completion of the project are present at Foster. All four dams have small-scale landslides that are currently active and cause short term damage to infrastructure that must be repaired.

**Removal of Geologic Material**

Under the NAA, removal of geologic materials is not expected at any project in this subbasin.

#### *3.4.2.2.2 Long Tom Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Fern Ridge reservoir remains above the minimum pool elevation in even dry years. There are no mapped landslides around the reservoir.

**Removal of Geologic Material**

Under the NAA, removal of geologic materials is not expected at any project in this subbasin.

#### *3.4.2.2.3 McKenzie Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Even in dry years the reservoir elevation does not go below the minimum pool elevation at Cougar and Blue River. Large and moderate size landslides are present around the Cougar reservoir and have experienced small scale movements resulting in minor rock fall and slumping since completion of the project.

**Removal of Geologic Material**

Under the NAA, removal of geologic materials is not expected at any project in this subbasin.

#### *3.4.2.2.4 Middle Fork of the Willamette Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Due to the injunction the Fall Creek pool is drawn down to elevation 680 ft NAVD88, which is below the rule curve minimum pool, annually in autumn. Hills Creek and Lookout Point reach the bottom of the conservation pool in about 5% of years, but does not go below the minimum pool elevation. Dexter is a run of river dam and has minimal storage. Hills Creek and Lookout Point have historic landslides around their reservoirs and Hills Creek has moderate sized landslides that have displayed small scale activity, resulting in road damage, since project completion. Hills Creek and Lookout Point have active small-scale landslides that have caused temporary damage to infrastructure that must be repaired and Fall Creek has small-scale ancient landslides around the reservoir.

**Removal of Geologic Material**

Under the NAA, removal of geologic materials is not expected at any project in this subbasin.

#### *3.4.2.2.5 Coast Fork of the Willamette Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Dorena and Cottage Grove reach the bottom of their conservation pool in the driest 5% of years but are not drafted below their minimum pool. Dorena has large ancient landslides mapped around the reservoir rim as well as several active small landslides that have damaged infrastructure and resulting in the need for periodic repairs to the roads and railroad around the Dorena reservoir. Cottage Grove does not have any landslides mapped around the reservoir rim.

**Removal of Geologic Material**

Under the NAA, removal of geologic materials is not expected at any project in this subbasin.

#### *3.4.2.2.6 Climate Change*

Increased variability in the spring precipitation may result in less reliable reservoir refill. Additionally, due to decreasing future summer and fall inflows, WVS projects may reach their minimum water surface elevations more frequently. Drawdown may be more rapid to meet downstream minimum flow targets, which presents some landslide risk to reservoirs that have existing plains of weakness. Deep drafts due to climate change may result in increased shoreline exposure, which may allow small-scale failures of newly exposed, unvegetated, erodible sediment to propagate into existing failures, resulting in reactivation of large-scale material movements. These effects are particularly present in the Santiam and Middle Fork subbasins because they may be drafted more than other WVS reservoirs.

##### *3.4.2.2.7 Summary of Effects of the No Action Alternative*

Under the NAA, negligible change is expected for the activation of landslides due to deep drawdown. The current regime of small-scale landslides being activated at roads and rail lines during wet weather will continue as described in the affected environments section. The negligible change in these metrics results from negligible change in water storage patterns, seasonal reservoir elevations, and loading of slopes due to seasonal precipitation.

#### ***3.4.2.3 Alternative 1 – Project Storage Alternative***

##### *3.4.2.3.1 Santiam Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Under Alternative 1, augmenting instream flows by using the power pool (#304) is proposed for Green Peter and Detroit and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Due to the moderate sized landslides that do not have a history of movement, environmental consequences at Green Peter Dam are expected to be minor. Based on the large landslides at Detroit Dam that do have a history of movement since the beginning of dam operations, the indirect adverse environmental effect from this measure is moderate compared to the NAA.

**Removal of Geologic Material**

This alternative includes constructing a water temperature control tower (#105) at Green Peter and Detroit, and constructing a structural downstream fish passage (#392) for Detroit, Foster, and Green Peter. These structures would likely require small-scale and localized rock excavation, which would have a minor direct effect on local geology compared to the NAA which does not include these structures.

##### *3.4.2.3.2 Long Tom Subbasin*

**Activation of Landslides Due to Deep Drawdown**

No measures that reduce the pool below the rule curve, active pool, or draft the reservoir down to the RO are included for Fern Ridge under this alternative. The effect of this alternative on local geology is none.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative on local geology is none.

#### *3.4.2.3.3 McKenzie Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Alternative 1 includes augmenting instream flows by using the power pool (#304) at Cougar and augmenting instream flows by using the inactive pool (#718) for Blue River, both of which result in an increase to shoreline exposure. Compared to the NAA there is the potential for moderate, indirect, adverse, local effects from large landslides that have a history of movement along the upstream reservoir rims at Cougar due to increased shoreline exposure from augmented instream flows from the power pool (#304). The effects from increased surface exposure augmenting instream flows by using the inactive pool (#718) at Blue River are expected to be negligible because only small-scale landslides are mapped in contact with the reservoir.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative on local geology is none.

#### *3.4.2.3.4 Middle Fork of the Willamette Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Alternative 1 includes augmenting instream flows by using the power pool (#304) at Lookout Point and Hills Creek and augmenting instream flows by using the inactive pool (#718) at Fall Creek. Augmentation of instream flows by using the inactive pool (#718) is not expected to result in a difference from the NAA at Fall Creek, but augmented instream flows from the power pool (#304) results in reservoir drawdowns below the NAA rule curve elevations and therefore an increase to shoreline exposure at Lookout Point and Hills Creek.

Due to the increase in shoreline exposure and presence of large landslides that do not have a history of movement there is potential for minor, indirect, adverse, local effects at Lookout Point from augmented instream flows from the power pool (#304). Hills Creek has moderate sized landslides with a history of movement so there is the potential for moderate indirect, adverse, local effects from landslides along the upstream reservoir rims due to augmented instream flows from the power pool (#304) compared to the NAA.

**Removal of Geologic Material**

Alternative 1 includes constructing a water temperature control tower (#105) at Lookout Point and Hills Creek and constructing structural downstream fish passage (#392) at Lookout Point which would require small-scale and localized rock excavation. This would have a minor direct effect on local geology compared with the NAA that does not include a WTC.

#### *3.4.2.3.5 Coast Fork of the Willamette Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Alternative 1 includes augmenting instream flows by using the inactive pool (#718) which results in reservoir drawdowns below the normal rule curve elevations at Cottage Grove and Dorena. Because there are large landslides mapped at Dorena that have no history of movement, this measure would have a minor, indirect, adverse, local effect on landslides compared to the NAA. No landslides are mapped around Cottage Grove, so the effect of drawdown would be negligible.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative on local geology is none.

#### *3.4.2.3.6 Climate Change*

Climate change would increase the probability of landslides due to deep drawdown under this alternative by three mechanisms: increasing the annual probability that a deep drawdown would occur, increasing the annual probability that major precipitation events would occur coincident with deep drawdown, and increasing the frequency of wildfires. Under Alternative 1, climate change is likely to enhance landslide risk at Cougar, Detroit, Dorena, Green Peter, Hills Creek, and Lookout Point compared with the NAA.

Due to decreasing future summer and fall inflows, WVS projects may reach their minimum water surface elevations more frequently and sooner in the year, which would increase the duration of shoreline exposure. This would increase the potential for erosion to undercut and destabilize slopes, which could result in an increased risk of slope failure during the next refill/drawdown cycle. Drawdown also may be more rapid to meet downstream minimum flow targets, which would mean a higher pore pressure differential between the slope and atmosphere could occur, increasing the risk of slope failure.

The WVS will likely experience increasing wintertime flow volumes in the future because of larger precipitation events and more precipitation falling as rain instead of snow. Intense rainfall is a triggering event for shallow landslides (Wieczorek, 1996). If large events were to occur coincident with deep drawdowns the exposed shoreline may saturate and cause shallow landslides that progress into larger debris flows and reactivate larger landslides in vulnerable slopes.

Increased variability in the spring rainfall, drier hotter summers, and lower summer baseflow mean that there is more potential for wildfires to impact the reservoir rim. Wildfire can produce a water repellent soil layer that increases overland flow through burnt forested areas (Wieczorek, 1996), and may lead to erosive undercutting of the exposed shoreline and saturation of unvegetated soils, which could lead to slope failure.

*3.4.2.3.7 Summary of Effects of Alternative 1*

**Table 3.4-3. Summary of effects for Geology and Soils under Alternative 1 as compared to the No Action Alternative**

| Basin and Project | Summary |
|---|---|
| Coast Fork Willamette - Cottage Grove | Augmentation from the inactive pool to meet flow targets at Cottage Grove would have a **negligible** effect on the activation of landslides due to no mapped landslides being in connection with the reservoir. |
| Coast Fork Willamette - Dorena | Augmentation from the inactive pool to meet flow targets at Dorena would increase shoreline exposure and would have a **minor** effect on the activation of landslides due to large and moderate mapped landslides that do not have a history of movement. |
| Long Tom - Fern Ridge | No measures that effect landslide formation are proposed for at Fern Ridge that would increase shoreline exposure, therefore effects are **negligible**. |
| McKenzie - Blue River | Augmentation from the inactive pool to meet flow targets at Blue River would increase shoreline exposure but would have a **negligible** effect on the activation of landslides because only small landslides are mapped around the reservoir. |
| McKenzie - Cougar | Augmentation from the power pool to meet flow targets at Cougar would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate sized mapped landslides that have a history of movement since project construction |
| Middle Fork Willamette - Dexter | No measures that effect landslide formation are proposed at Dexter that would increase shoreline exposure, therefore effects are **negligible**. |
| Middle Fork Willamette - Fall Creek | Augmentation from the inactive pool to meet flow targets at Fall Creek would not increase shoreline exposure and would have a **negligible** effect on the activation of landslides |
| Middle Fork Willamette - Hills Creek | Augmentation from the power pool to meet flow targets at Hills Creek would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate mapped landslides that have a history of movement since project construction |
| Middle Fork Willamette - Lookout Point | Augmentation from the power pool to meet flow targets at Lookout Point would increase shoreline exposure and would have a **minor** effect on the activation of landslides due to large and moderate mapped landslides that do not have a history of movement. Construction of a temperature control tower and |

| Basin and Project | Summary |
|---|---|
| | structural downstream passage at Lookout Point would result in minor local removal of geologic materials. |
| Santiam - Big Cliff | No measures that effect landslide formation are proposed for at Big Cliff that would increase shoreline exposure, therefore effects are **negligible**. |
| Santiam - Detroit | Augmentation from the power pool to meet flow targets at Detroit would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate sized mapped landslides that have a history of movement since project construction. Construction of a temperature control tower and structural downstream passage at Detroit would result in minor local removal of geologic materials. |
| Santiam - Foster | No measures that effect landslide formation are proposed at Foster that would increase shoreline exposure, therefore effects are **negligible**. Construction of a structural downstream passage at Foster would result in **minor** local removal of geologic materials. |
| Santiam - Green Peter | Augmentation from the power pool to meet flow targets at Green Peter would increase shoreline exposure and would have a **minor** effect on the activation of landslides due to large and moderate mapped landslides that do not have a history of movement since project completion. Construction of a temperature control tower and structural downstream passage at Green Peter would result in minor local removal of geologic materials. |

#### *3.4.2.4 Alternative 2A -- Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

##### *3.4.2.4.1 Santiam Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Under Alternative 2A, augmenting instream flows by using the power pool (#304) is proposed for Green Peter and Detroit, which would allow these projects to drawdown below the power pool to augment flows and which increases shoreline exposure relative to the NAA. Deeper fall reservoir drawdowns for fish passage (#40) under Alternative 2A would allow deep reservoir drawdown to within 25 feet of the RO invert at Green Peter, which also increases shoreline exposure.

Green Peter has moderate-sized landslides that have not experienced movement since project initiation. Therefore, the combined increase in shoreline exposure due to deep fall reservoir drawdown (#40) and augmented instream flows from the power pool (#304) have the potential to initiate minor, indirect, adverse, local effects from landslides around the reservoir's rim compared to the NAA. Based on the moderate-sized landslides at Detroit Dam that do have a history of movement since the beginning of dam operations, augmented instream flows from the power pool (#304) has some potential to initiate indirect, moderate, adverse, local effects from landslides around the reservoir's rim. Increases in shoreline exposure at Big Cliff would have a negligible effect on the activation of landslides due to only small landslides being present in connection to the reservoir compared to the NAA.

**Removal of Geologic Material**

This alternative includes constructing a water temperature control tower (#105) at Detroit and constructing structural downstream fish passage (#392) for Foster and Detroit. These structures would likely require small-scale and localized rock excavation. This would have a minor direct effect on local geology compared to the NAA.

*3.4.2.4.2 Long Tom Subbasin*

**Activation of Landslides Due to Deep Drawdown**

No measures that reduce the pool below the rule curve, active pool, or draft the reservoir down to the RO are included for Fern Ridge under this alternative. The effect of this alternative on local geology is none.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative on local geology is none.

*3.4.2.4.3 McKenzie Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Alternative 2A includes augmenting instream flows by using the power pool (#304) for Blue River and augmenting instream flows by using the inactive pool (#718) for Cougar. Both measures result in increased shoreline exposure compared with the NAA. Because of the presence of large landslides with a history of movement mapped around the Cougar reservoir, there is the potential for moderate, indirect, adverse, local effects from landslides at Cougar due to augmented instream flows from the power pool (#304) compared to the NAA. The effects from augmentation of instream flows by using the inactive pool (#718) at Blue River would be negligible because Blue River only has small-scale landslides mapped near the reservoir.

**Removal of Geologic Material**

This alternative includes constructing structural downstream fish passage (#392) for Cougar. These structures would likely require small-scale and localized rock excavation, which would have a minor local effect compared to the NAA.

#### *3.4.2.4.4 Middle Fork of the Willamette Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Alternative 2A includes augmenting instream flows by using the power pool (#304) for Lookout Point and Hills Creek, which increases shoreline exposure compared with the NAA. Augmenting instream flows by using the inactive pool (#718) is proposed for Fall Creek, but would not increase shoreline exposure compared with the NAA so the effect of this measure is negligible. Due to the increase in shoreline exposure and presence of large landslides that do not have a history of movement at Lookout Point, there is some potential for minor, indirect, adverse, local effects due to this alternative. There is the potential for moderate, indirect, adverse, local effects from landslides that have a history of movement along the upstream reservoir rims at Hills Creek due to the increase in shoreline exposure under this alternative compared to the NAA.

**Removal of Geologic Material**

This alternative includes constructing structural downstream fish passage (#392) at Lookout Point which would require small-scale and localized rock excavation. This would have a minor direct effect on local geology.

#### *3.4.2.4.5 Coast Fork of the Willamette Subbasin*

**Activation of Landslides Due to Deep Drawdown**

No measures that reduce the pool below the rule curve, active pool, or draft the reservoir down to the RO are included under this alternative. The effect of this alternative is none.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative is none.

#### *3.4.2.4.6 Evaluation of Near-Term Operations Measure*

#### *3.4.2.4.7 Santiam Subbasin*

The near-term operations (NTO) measure within the North Santiam Basin includes Fall/Winter downstream fish passage through the upper regulating outlets, spring fish passage through strategic use of spillway and turbines at Detroit Dam and spreading spill to reduce total dissolved gas at Big Cliff Dam. The near-term operations measure within the South Santiam Subbasin include outplanting of adult Chinook above Green Peter Reservoir, downstream fish passage at Green Peter Dam via the spillway in the spring and fall, deep drawdown and RO prioritization for downstream fish passage, and downstream fish passage at Foster via the spillway in the spring and fall.

**Activation of Landslides Due to Deep Drawdown**

The near-term operations measure involves allowing deep reservoir drawdown to within 35 feet of the RO invert at Green Peter. Green Peter has moderate-sized landslides that have not experienced movement since project initiation, therefore, the near-term operations measure has some potential to initiate minor, indirect, adverse, local effects from landslides around the reservoir's rim compared to the NAA. Although the near-term operations at Detroit themselves do not affect reservoir levels, their combined effect on outflow in drier years results in increased shoreline exposure, which would have a moderate, indirect, adverse, local effect from landslides around the reservoir rim that have experienced movement since project completion compared to the NAA.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under the near-term operations measure. There would be negligible effect resulting from this measure.

*3.4.2.4.8 Long Tom Subbasin*

There are no local operations proposed under the near-term operations measure within the Long Tom subbasin.

**Activation of Landslides Due to Deep Drawdown**

The near-term operations measure would not reduce the pool below the rule curve, active pool, or draft the reservoir down to the RO, therefore, there would be negligible effect.

**Removal of Geologic Material**

The near-term operations measure would not result in excavation of geologic materials, therefore, there would be negligible effect.

*3.4.2.4.9 McKenzie Subbasin*

The near-term operations measures within the McKenzie Subbasin includes spring and fall drawdown for fish passage at Cougar Reservoir to a target elevation of 1505 feet and delayed reservoir refill and RO prioritization for improved downstream fish passage compared to the NAA.

**Activation of Landslides Due to Deep Drawdown**

Cougar has large- and moderate-sized landslides that have experienced movement since project initiation, therefore, increased shoreline exposure due to the near-term operation measures have some potential to initiate major, indirect, adverse, local effects from landslides around the reservoirs rim.

**Removal of Geologic Material**

The near-term operations measure would not result in excavation of geologic materials, therefore, there would be negligible effect.

#### *3.4.2.4.10 Middle Fork of the Willamette River Subbasin*

The near-term operations measure within the Middle Fork Willamette Subbasin includes use of the regulating outlet for downstream fish passage at Hills Creek , deep drawdown for fish passage at Lookout Point in winter, use of the spillway for fish passage at Lookout Point in the spring, use of the Lookout Point regulating outlets for temperature management in the summer and fall, and deep drawdown in the fall and delayed refill in the spring for fish passage at Fall Creek. For the operations at Lookout Point, storage at Hills Creek would be used for refilling Lookout Point in early March.

**Activation of Landslides Due to Deep Drawdown**

The near-term operations measure involves deep drawdown to a target elevation of 761 ft NAVD88, 50 ft over the top of the penstock at Lookout Point. Due to the presence of large landslides that do not have a history of movement at Lookout Point, there is some potential for minor, indirect, adverse, local effects due to the increased shoreline exposure from the near-term operations measure. The near-term operations require Detroit to prioritize refilling Lookout Point after fall drawdowns, so in winter after a dry year Hills Creek Reservoir may reach lower minimum elevations than under the NAA. The change the operating range of the reservoir results in increased shoreline exposure, which would have a moderate, indirect, adverse, local effect from landslides around the reservoir rim that have experienced movement since project completion at Hills Creek.

**Removal of Geologic Material**

The near-term operations measure would not result in excavation of geologic materials, therefore, there would be negligible effect.

#### *3.4.2.4.11 Coast Fork of the Willamette River Subbasin*

There are no local operations proposed under the near-term operations measure within the Coast Fork subbasin.

**Activation of Landslides Due to Deep Drawdown**

The near-term operations measure would not reduce the pool below the rule curve, active pool, or draft the reservoir down to the RO, therefore, there would be negligible effect.

**Removal of Geologic Material**

The near-term operations measure would not result in excavation of geologic materials, therefore, there would be negligible effect.

*3.4.2.4.12 Climate Change*

Climate change would increase the probability of initiation of landslides due to deep drawdown under this alternative by three mechanisms: increasing the annual probability that a deep drawdown would occur, increasing the annual probability that major precipitation events would occur coincident with deep drawdown, and increasing the frequency of wildfires. Under Alternative 2A, climate change is likely to enhance landslide risk at Cougar, Detroit, Green Peter, and Hills Creek compared with the NAA.

Due to decreasing future summer and fall inflows, WVS projects may reach their minimum water surface elevations more frequently and sooner in the year, which would increase the duration of shoreline exposure. This would increase the potential for erosion to undercut and destabilize slopes, which could result in an increased risk of slope failure during the next refill/drawdown cycle. Drawdown also may be more rapid to meet downstream minimum flow targets, which would mean a higher pore pressure differential between the slope and atmosphere could occur, increasing the risk of slope failure.

The WVS will likely experience increasing wintertime flow volumes in the future because of larger precipitation events and more precipitation falling as rain instead of snow. Intense rainfall is a triggering event for shallow landslides (Wieczorek, 1996). If large events were to occur coincident with deep drawdowns, the exposed shoreline may saturate and cause shallow landslides that progress into larger debris flows and reactivate larger landslides in vulnerable slopes.

Increased variability in the spring rainfall, drier hotter summers, and lower summer baseflow mean that there is more potential for wildfires to impact the reservoir rim. Wildfire can produce a water repellent soil layer that increases overland flow through burnt forested areas (Wieczorek, 1996), and may lead to erosive undercutting of the exposed shoreline and saturation of unvegetated soils, which could lead to slope failure.

*3.4.2.4.13 Summary of Effects of Alternative 2A*

**Table 3.4-4. Summary of effects for Geology and Soils under Alternative 2A as compared to the No Action Alternative**

| Basin and Project | Summary |
|---|---|
| Coast Fork Willamette - Cottage Grove | No measures that effect landslide formation are proposed for at Cottage Grove that would increase shoreline exposure, therefore effects are **negligible**. |

| Basin and Project | Summary |
|---|---|
| Coast Fork Willamette - Dorena | No measures that effect landslide formation are proposed for at Dorena that would increase shoreline exposure, therefore effects are **negligible**. |
| Long Tom - Fern Ridge | No measures that effect landslide formation are proposed for at Fern Ridge that would increase shoreline exposure, therefore effects are **negligible**. |
| McKenzie - Blue River | Augmentation from the inactive pool to meet flow targets at Blue River would increase shoreline exposure, but would have a **negligible** effect on the activation of landslides because only small landslides are mapped around the reservoir. |
| McKenzie - Cougar | Augmentation from the power pool to meet flow targets at Cougar would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate mapped landslides that have a history of movement since project construction. Construction of a structural downstream passage at Cougar would result in **minor** local removal of geologic materials. |
| Middle Fork Willamette - Dexter | No measures that effect landslide formation are proposed at Dexter that would increase shoreline exposure, therefore effects are **negligible**. |
| Middle Fork Willamette - Fall Creek | Augmentation from the inactive pool to meet flow targets at Fall Creek would not increase shoreline exposure and would have a **negligible** effect on the activation of landslides |
| Middle Fork Willamette - Hills Creek | Augmentation from the power pool to meet flow targets at Hills Creek would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate mapped landslides that have a history of movement since project construction |
| Middle Fork Willamette - Lookout Point | Augmentation from the power pool to meet flow targets at Lookout Point would increase shoreline exposure and would have a **minor** effect on the activation of landslides due to large and moderate mapped landslides that do not have a history of movement. Construction of a structural downstream passage at Lookout Point would result in **minor** local removal of geologic materials. |
| Santiam - Big Cliff | No measures that effect landslide formation are proposed for at Big Cliff that would increase shoreline exposure, therefore effects are **negligible**. |
| Santiam - Detroit | Augmentation from the power pool to meet flow targets at Detroit would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and |

| Basin and Project | Summary |
|---|---|
| | moderate sized mapped landslides that have a history of movement since project construction. Construction of a temperature control tower and structural downstream passage at Detroit would result in **minor** local removal of geologic materials. |
| Santiam - Foster | No measures that effect landslide formation are proposed at Foster that would increase shoreline exposure, therefore effects are **negligible**. Construction of a structural downstream passage at Foster would result in **minor** local removal of geologic materials. |
| Santiam - Green Peter | Augmentation from the power pool to meet flow targets and deep drawdowns to near the RO in fall at Green Peter would increase shoreline exposure and would have a **minor** effect on the activation of landslides due to large and moderate sized mapped landslides that do not have a history of movement since project completion. |

#### *3.4.2.5 Alternative 2B -- Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

##### *3.4.2.5.1 Santiam Subbasin*

**<u>Activation of Landslides Due to Deep Drawdown</u>**

Augmenting instream flows by using the power pool (#304) is proposed for Green Peter and Detroit under Alternative 2B. Deeper fall reservoir drawdowns for fish passage (#40) would allow deep reservoir drawdown to within 25 feet of the RO invert in fall at Green Peter.

Green Peter has moderate-sized landslides that have not experienced movement since project initiation, therefore increased shoreline exposure due to deeper fall reservoir drawdowns for fish passage (#40) and augmented instream flows from the power pool (#304) have some potential to initiate minor, indirect, adverse, local effects from landslides around the reservoir's rim. Based on the moderate-sized landslides at Detroit Dam that have a history of movement since the beginning of dam operations, augmented instream flows from the power pool (#304) has some potential to initiate moderate, indirect, adverse, local effects from landslides around the reservoir's rim.

**<u>Removal of Geologic Material</u>**

This alternative includes constructing a water temperature control tower (#105) at Detroit and constructing structural downstream fish passage (#392) for Foster and Detroit. These structures would likely require small-scale and localized rock excavation. This would have a minor direct effect on local geology at both Foster and Detroit compared to the NAA.

#### *3.4.2.5.2 Long Tom Subbasin*

**Activation of Landslides Due to Deep Drawdown**

No measures that reduce the pool below the rule curve, active pool, or draft the reservoir down to the RO are included for Fern Ridge under this alternative. The effect of this alternative on local geology is none.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative on local geology is none.

#### *3.4.2.5.3 McKenzie Subbasin*

**Activation of Landslides Due to Deep Drawdown**

This alternative includes augmenting instream flows by using the power pool (#304) for Blue River and augmenting instream flows by using the inactive pool (#718) for Cougar both of which results in reservoir drawdowns below the normal rule curve elevations. At Cougar deeper fall reservoir drawdowns for fish passage (#40) would allow deep reservoir drawdown to within 10 feet of the RO invert during the fall season and spring reservoir drawdown for downstream fish passage (#720) proposes use of the diversion tunnel and drawdown to streambed. Based on the presence of landslides at Cougar that have shown some small-scale movement since project initiation there is the potential for moderate, indirect, adverse, local effects from landslides along the upstream reservoir rims because of increased shoreline exposure due to deeper fall reservoir drawdowns for fish passage (#40), augmented instream flows from the power pool (#304), and spring reservoir drawdown for downstream fish passage (#720) compared to the NAA. The effects from augmentation of instream flows by using the inactive pool (#718) at Blue River are expected to be negligible because no landslides are mapped in contact with the reservoir.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative on local geology is none.

#### *3.4.2.5.4 Middle Fork of the Willamette Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point and Hills Creek and augmenting instream flows by using the inactive pool (#718) is proposed for Fall Creek. Augmentation from the inactive pool to meet flow targets (#718) at Fall Creek would not increase shoreline exposure and would have a negligible effect on the activation of landslides. Due to the presence of large landslides that do not have a history of movement, there is the potential for minor, indirect, adverse, local effects at Lookout Point due to increased shoreline exposure from augmented instream flows from the power pool (#304). Based on the presence of landslides at Hills Creek that have shown some small-scale movement since project initiation, there is the potential for moderate, indirect, adverse, local effects from increased shoreline exposure due to augmented instream flows from the power pool (#304) compared to the NAA.

**Removal of Geologic Material**

This alternative includes constructing structural downstream fish passage (#392) at Lookout Point which would require localized rock excavation. This would have a minor direct effect on local geology.

*3.4.2.5.5 Coast Fork of the Willamette Subbasin*

**Activation of Landslides Due to Deep Drawdown**

No measures that reduce the pool below the rule curve, active pool, or draft the reservoir down to the RO are included under this alternative. The effect of this alternative is none.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative is none.

*3.4.2.5.6 Near Term Operations Measures*

See Alternative 2A, Section 0, for description of effects due to the Near-Term Operations Measure.

*3.4.2.5.7 Climate Change*

Climate change would increase the probability of initiation of landslides due to deep drawdown under this alternative by three mechanisms: increasing the annual probability that a deep drawdown would occur, increasing the annual probability that major precipitation events would occur coincident with deep drawdown, and increasing the frequency of wildfires. Under Alternative 2B climate change is likely to enhance landslide risk at Cougar, Detroit, Green Peter, and Hills Creek compared with the NAA.

Due to decreasing future summer and fall inflows, WVS projects may reach their minimum water surface elevations more frequently and sooner in the year, which would increase the duration of shoreline exposure. This would increase the potential for erosion to undercut and destabilize slopes, which could result in an increased risk of slope failure during the next refill/drawdown cycle. Drawdown also may be more rapid to meet downstream minimum flow targets, which would mean a higher pore pressure differential between the slope and atmosphere could occur, increasing the risk of slope failure.

The WVS would likely experience increasing wintertime flow volumes in the future because of larger precipitation events and more precipitation falling as rain instead of snow. Intense rainfall is a triggering event for shallow landslides (Wieczorek, 1996). If large events were to occur coincident with deep drawdowns, the exposed shoreline may saturate and cause shallow landslides that progress into larger debris flows and reactivate larger landslides in vulnerable slopes.

Increased variability in the spring rainfall, drier hotter summers, and lower summer baseflow mean that there is more potential for wildfires to impact the reservoir rim. Wildfire can produce a water repellent soil layer that increases overland flow through burnt forested areas (Wieczorek, 1996), and may lead to erosive undercutting of the exposed shoreline and saturation of unvegetated soils, which could lead to slope failure.

##### *3.4.2.5.8 Summary of Effects of Alternative 2B*

**Table 3.4-5. Summary of effects for Geology and Soils under Alternative 2B as compared to the No Action Alternative**

| Basin and Project | Summary |
|---|---|
| Coast Fork Willamette - Cottage Grove | No measures that effect landslide formation are proposed for at Cottage Grove that would increase shoreline exposure, therefore effects are **negligible**. |
| Coast Fork Willamette - Dorena | No measures that effect landslide formation are proposed for at Dorena that would increase shoreline exposure, therefore effects are **negligible**. |
| Long Tom - Fern Ridge | No measures that effect landslide formation are proposed for at Fern Ridge that would increase shoreline exposure, therefore effects are **negligible**. |
| McKenzie - Blue River | Augmentation from the inactive pool to meet flow targets at Blue River would increase shoreline exposure but would have a **negligible** effect on the activation of landslides because only small landslides are mapped around the reservoir. |
| McKenzie - Cougar | Augmentation from the power pool to meet flow targets and deep drawdowns to near the RO in fall at Cougar would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate mapped landslides that have a history of movement since project construction. |
| Middle Fork Willamette - Dexter | No measures that effect landslide formation are proposed for Dexter that would increase shoreline exposure, therefore effects are **negligible**. |
| Middle Fork Willamette - Fall Creek | Augmentation from the inactive pool to meet flow targets at Fall Creek would not increase shoreline exposure and would have a **negligible** effect on the activation of landslides. |

| Basin and Project | Summary |
|---|---|
| Middle Fork Willamette - Hills Creek | Augmentation from the power pool to meet flow targets at Hills Creek would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate sized mapped landslides that have a history of movement since project construction. |
| Middle Fork Willamette - Lookout Point | Augmentation from the power pool to meet flow targets at Lookout Point would increase shoreline exposure and would have a **minor** effect on the activation of landslides due to large and moderate mapped landslides that do not have a history of movement. Construction of a structural downstream passage at Lookout Point would result in **minor** local removal of geologic materials. |
| Santiam - Big Cliff | No measures that effect landslide formation are proposed for Big Cliff that would increase shoreline exposure, therefore effects are **negligible**. |
| Santiam - Detroit | Augmentation from the power pool to meet flow targets at Detroit would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate sized mapped landslides that have a history of movement since project construction. Construction of a temperature control tower and structural downstream passage at Detroit would result in **minor** local removal of geologic materials. |
| Santiam - Foster | No measures that effect landslide formation are proposed at Foster that would increase shoreline exposure, therefore effects are **negligible**. Construction of a structural downstream passage at Foster would result in **minor** local removal of geologic materials. |
| Santiam - Green Peter | Augmentation from the power pool to meet flow targets and deep drawdowns to near the RO in fall at Green Peter would increase shoreline exposure and would have a **minor** effect on the activation of landslides due to large and moderate sized mapped landslides that do not have a history of movement since project completion. |

### *3.4.2.6 Alternative 3A – Operations-Focused Fish Passage Alternative*

#### *3.4.2.6.1 Santiam Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Under Alternative 3A, augmenting instream flows by using the power pool (#304) is proposed for Green Peter and Detroit and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Under Alternative 3A, deeper fall reservoir drawdowns (#40) for Detroit and Green Peter and spring reservoir drawdowns (#720) for Detroit allow deep reservoir drawdown to within 25 feet of the RO.

Green Peter has moderate-sized landslides that have not experienced movement since project initiation, therefore increased shoreline exposure due to deeper fall reservoir drawdowns for fish passage (#40) and augmented instream flows from the power pool (#304) have some potential to initiate minor indirect adverse local effects. Based on the moderate sized landslides at Detroit Dam that have a history of movement since the beginning of dam operations, deeper fall reservoir drawdowns for fish passage (#40), augmented instream flows from the power pool (#304), and spring reservoir drawdown for downstream fish passage (#720) have some potential to initiate moderate, indirect, adverse, local effects compared to the NAA.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative is none.

#### *3.4.2.6.2 Long Tom Subbasin*

**Activation of Landslides Due to Deep Drawdown**

No measures that reduce the pool below the rule curve, active pool, or draft the reservoir down to the RO are included for Fern Ridge under this alternative. The effect of this alternative on local geology is none.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative on local geology is none.

#### *3.4.2.6.3 McKenzie Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Alternative 3A includes augmenting instream flows by using the inactive pool (#718) for Blue River and augmenting instream flows by using the power pool (#304) for Cougar both of which results in reservoir drawdowns below the normal rule curve elevations. Deeper fall reservoir drawdowns for fish passage (#40) would allow deep reservoir drawdown to within 25 feet of the RO invert in fall at Blue River. There is the potential for moderate, indirect, adverse, local effects from landslides along the upstream reservoir rims at Cougar from increased shoreline exposure due to augmented instream flows from the power pool (#304) due to the presence of large landslides that have a history of movement since project completion compared to the NAA. Because Blue River does not have landslides in contact with the reservoir, the effects from deeper fall reservoir drawdowns for fish passage (#40) and augmentation of instream flows by using the inactive pool (#718) are expected to be negligible.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative for this subbasin. The effect of this alternative on local geology is none.

##### *3.4.2.6.4 Middle Fork of the Willamette Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Under Alternative 3A, augmenting of instream flows by using the power pool (#304) is proposed for Lookout Point and Hills Creek and augmenting instream flows by using the inactive pool (#718) is proposed for Fall Creek. Deeper fall reservoir drawdowns (#40) is proposed for both Lookout Point and Hills Creek and a spring reservoir drawdown (#720) is proposed for Lookout Point.

No increase in shoreline exposure is anticipated at Fall Creek under Alternative 3A, so the effect from augmentation of instream flows by using the inactive pool (#718) at Fall Creek would be negligible. Due to large landslides with no history of movement since project completion in contact with the reservoir at Lookout Point, there is the potential for minor, indirect, adverse, local effects from increased shoreline exposure due to deeper fall reservoir drawdowns for fish passage (#40), augmented instream flows from the power pool (#304), and spring reservoir drawdown for downstream fish passage (#720) compared to the NAA. Deeper fall reservoir drawdowns for fish passage (#40) and augmented instream flows from the power pool (#304) at Hills Creek would have moderate indirect adverse local effects due to large landslides that have a history of movement since project completion in contact with the reservoir.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative for this subbasin. The effect of this alternative on local geology is none.

##### *3.4.2.6.5 Coast Fork of the Willamette Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Alternative 3A also includes augmenting instream flows by using the inactive pool (#718) at Cottage Grove and Dorena. Because there are large landslides mapped at Dorena that have no history of movement, this measure is expected to have a minor direct effect on landslides. No landslides are mapped around the reservoir at Cottage Grove, so the effects would be negligible compared to the NAA.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative is none.

*3.4.2.6.6 Near Term Operations Measures*

See Alternative 2A, Section 0, for description of effects due to the Near-Term Operations Measure.

*3.4.2.6.7 Climate Change*

Climate change would increase the probability of initiation of landslides due to deep drawdown under this alternative by three mechanisms: increasing the annual probability that a deep drawdown would occur, increasing the annual probability that major precipitation events would occur coincident with deep drawdown, and increasing the frequency of wildfires. Under Alternative 3A, climate change is likely to enhance landslide risk at Cougar, Detroit, Dorena, Green Peter, and Lookout Point compared with the NAA.

Due to decreasing future summer and fall inflows, WVS projects may reach their minimum water surface elevations more frequently and sooner in the year, which would increase the duration of shoreline exposure. This would increase the potential for erosion to undercut and destabilize slopes, which could result in an increased risk of slope failure during the next refill/drawdown cycle. Drawdown also may be more rapid to meet downstream minimum flow targets, which would mean a higher pore pressure differential between the slope and atmosphere could occur, increasing the risk of slope failure.

The WVS would likely experience increasing wintertime flow volumes in the future because of larger precipitation events and more precipitation falling as rain instead of snow. Intense rainfall is a triggering event for shallow landslides (Wieczorek, 1996). If large events were to occur coincident with deep drawdowns the exposed shoreline may saturate and cause shallow landslides that progress into larger debris flows and reactivate larger landslides in vulnerable slopes.

Increased variability in the spring rainfall, drier hotter summers, and lower summer baseflow mean that there is more potential for wildfires to impact the reservoir rim. Wildfire can produce a water repellent soil layer that increases overland flow through burnt forested areas (Wieczorek, 1996), and may lead to erosive undercutting of the exposed shoreline and saturation of unvegetated soils, which could lead to slope failure.

### *3.4.2.6.8 Summary of Effects of Alternative 3A*

**Table 3.4-6. Summary of effects for Geology and Soils under Alternative 3A as compared to the No Action Alternative**

| Basin and Project | Summary |
|---|---|
| Coast Fork Willamette - Cottage Grove | Augmentation from the inactive pool to meet flow targets at Cottage Grove would have a **negligible** effect on the activation of landslides due to no mapped landslides being in connection with the reservoir. |
| Coast Fork Willamette - Dorena | Augmentation from the inactive pool to meet flow targets at Dorena would increase shoreline exposure and would have a **minor** effect on the activation of landslides due to large and moderate sized mapped landslides that do not have a history of movement since project completion. |
| Long Tom - Fern Ridge | No measures that effect landslide formation are proposed for Fern Ridge that would increase shoreline exposure, therefore effects are **negligible**. |
| McKenzie - Blue River | Augmentation from the inactive pool to meet flow targets and deep drawdowns to near the RO in fall at Blue River would increase shoreline exposure but would have a **negligible** effect on the activation of landslides because only small landslides are mapped around the reservoir. |
| McKenzie - Cougar | Augmentation from the power pool to meet flow targets at Cougar would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate sized mapped landslides that have a history of movement since project construction |
| Middle Fork Willamette - Dexter | No measures that effect landslide formation are proposed at Dexter would increase shoreline exposure, therefore effects are **negligible**. |
| Middle Fork Willamette - Fall Creek | Augmentation from the inactive pool to meet flow targets at Fall Creek would not increase shoreline exposure and would have a **negligible** effect on the activation of landslides |
| Middle Fork Willamette - Hills Creek | Augmentation from the inactive pool to meet flow targets and deep drawdowns to near the RO in fall at Hills Creek would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate sized mapped landslides that have a history of movement since project construction |
| Middle Fork Willamette - Lookout Point | Augmentation from the power pool to meet flow targets and deep drawdowns to near the RO in fall and spring at Lookout Point would increase shoreline exposure and would have a |

| Basin and Project | Summary |
|---|---|
| | **minor** effect on the activation of landslides due to large and moderate sized mapped landslides that do not have a history of movement. |
| Santiam - Big Cliff | No measures that effect landslide formation are proposed for at Big Cliff that would increase shoreline exposure, therefore effects are **negligible**. |
| Santiam - Detroit | Augmentation from the power pool to meet flow targets and deep drawdowns to near the RO in fall and spring at Detroit would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate sized mapped landslides that have a history of movement since project construction |
| Santiam - Foster | No measures that effect landslide formation are proposed at Foster that would increase shoreline exposure, therefore effects are **negligible**. |
| Santiam - Green Peter | Augmentation from the power pool to meet flow targets and deep drawdowns to near the RO in fall at Green Peter would increase shoreline exposure and would have a **minor** effect on the activation of landslides due to large and moderate sized mapped landslides that do not have a history of movement since project completion. |

#### *3.4.2.7 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at COU)*

##### *3.4.2.7.1 Santiam Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Under Alternative 3B, augmenting instream flows by using the power pool (#304) is proposed for Green Peter and Detroit. Deep reservoir drawdown to within 25 feet of the RO at in fall at Green Peter (#40) and spring reservoir drawdown at Detroit (#720).

Green Peter has moderate-sized landslides that have not experienced movement since project initiation, therefore increased shoreline exposure due to deeper fall reservoir drawdowns for fish passage (#40), augmented instream flows from the power pool (#304), and spring reservoir drawdown for downstream fish passage (#720) have some potential to initiate minor, adverse, local effects from landslides around the reservoir's rim. Based on the moderate-sized landslides at Detroit Dam that do have a history of movement since the beginning of dam operations, increased shoreline exposure due to deeper fall reservoir drawdowns for fish passage (#40) and augmented instream flows from the power pool (#304) has some potential to initiate moderate, indirect, adverse, local effects from landslides around the reservoir's rim compared to the NAA.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative is none.

*3.4.2.7.2 Long Tom Subbasin*

**Activation of Landslides Due to Deep Drawdown**

No measures that reduce the pool below the rule curve, active pool, or draft the reservoir down to the RO are included for Fern Ridge under this alternative.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative.

*3.4.2.7.3 McKenzie Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Under Alternative 3B, augmenting instream flows by using the inactive pool (#718) is proposed for Blue River which results in reservoir drawdowns below the normal rule curve elevations. Deeper fall reservoir drawdowns (#40) is proposed at Cougar and Blue River, additionally spring reservoir drawdown (#720) at Cougar. Because large landslides that have history of movement since project construction are present at Cougar, there is the potential for moderate, indirect, adverse, local effects from increased shoreline exposure due to deeper fall reservoir drawdowns for fish passage (#40) and spring reservoir drawdown for downstream fish passage (#720) compared to the NAA. Only small landslides are mapped around the Blue River reservoir so effects from deeper fall reservoir drawdowns for fish passage (#40) and augmentation of instream flows by using the inactive pool (#718) would be negligible.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative on local geology is none.

*3.4.2.7.4 Middle Fork of the Willamette Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Alternative 3B includes augmenting instream flows by using the power pool (#304) at Lookout Point and Hills Creek, and augmenting instream flows by using the inactive pool (#718) to at Fall Creek. Deeper fall reservoir drawdowns (#40) at Lookout Point and Hills Creek and spring reservoir drawdown for downstream fish passage (#720) at Hills Creek are proposed.

Because large landslides with a history of movement since project completion are present at Hills Creek, there is the potential for moderate, indirect, adverse, local effects from landslides along the upstream reservoir rims due to deeper fall reservoir drawdowns for fish passage (#40), augmented instream flows from the power pool (#304), and spring reservoir drawdown for downstream fish passage (#720) are expected compared to the NAA. Because large landslides without a history of movement since project completion are present at Lookout Point, there is the potential for minor, indirect, adverse, local effects from landslides along the upstream reservoir rims due to deeper fall reservoir drawdowns for fish passage (#40) and augmented instream flows from the power pool (#304) are expected compared to the NAA. No increase in shoreline exposure is anticipated at Fall Creek, so the effect from augmentation of instream flows by using the inactive pool (#718) at Fall Creek would be negligible.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative for this subbasin. The effect of this alternative on local geology is none.

*3.4.2.7.5 Coast Fork of the Willamette Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Alternative 3B includes augmenting instream flows by using the inactive pool (#718), which results in reservoir drawdowns below the normal rule curve elevations at Cottage Grove and Dorena. Because there are large landslides mapped at Dorena that have no history of movement, this measure would have a minor, indirect, adverse, local effect on landslides. No landslides are mapped around Cottage Grove, so the effect of drawdown would be negligible compared to the NAA.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative is none.

*3.4.2.7.6 Near Term Operations Measures*

See Alternative 2A, Section 0, for description of effects due to the Near-Term Operations Measure.

*3.4.2.7.7 Climate Change*

Climate change would increase the probability of initiation of landslides due to deep drawdown under this alternative by three mechanisms: increasing the annual probability that a deep drawdown would occur, increasing the annual probability that major precipitation events would occur coincident with deep drawdown, and increasing the frequency of wildfires. Under Alternative 3B, climate change is likely to enhance landslide risk at Cougar, Detroit, Dorena, Green Peter, and Lookout Point compared with the NAA.

Due to decreasing future summer and fall inflows, WVS projects may reach their minimum water surface elevations more frequently and sooner in the year, which would increase the duration of shoreline exposure. This would increase the potential for erosion to undercut and destabilize slopes, which could result in an increased risk of slope failure during the next refill/drawdown cycle. Drawdown also may be more rapid to meet downstream minimum flow targets, which would mean a higher pore pressure differential between the slope and atmosphere could occur, increasing the risk of slope failure.

The WVS would likely experience increasing wintertime flow volumes in the future because of larger precipitation events and more precipitation falling as rain instead of snow. Intense rainfall is a triggering event for shallow landslides (Wieczorek, 1996). If large events were to occur coincident with deep drawdowns the exposed shoreline may saturate and cause shallow landslides that progress into larger debris flows and reactivate larger landslides in vulnerable slopes.

Increased variability in the spring rainfall, drier hotter summers, and lower summer baseflow mean that there is more potential for wildfires to impact the reservoir rim. Wildfire can produce a water repellent soil layer that increases overland flow through burnt forested areas (Wieczorek, 1996), and may lead to erosive undercutting of the exposed shoreline and saturation of unvegetated soils, which could lead to slope failure.

#### *3.4.2.7.8 Summary of Effects of Alternative 3B*

**Table 3.4-7. Summary of effects for Geology and Soils under Alternative 3B as compared to the No Action Alternative**

| Basin and Project | Summary |
|---|---|
| Coast Fork Willamette - Cottage Grove | Augmentation from the inactive pool to meet flow targets at Cottage Grove would have a **negligible** effect on the activation of landslides due to no mapped landslides being in connection with the reservoir. |
| Coast Fork Willamette - Dorena | Augmentation from the inactive pool to meet flow targets at Dorena would increase shoreline exposure and would have a **minor** effect on the activation of landslides due to large and moderate sized mapped landslides that do not have a history of movement. |
| Long Tom - Fern Ridge | No measures that effect landslide formation are proposed for at Fern Ridge that would increase shoreline exposure, therefore effects are **negligible**. |
| McKenzie - Blue River | Augmentation from the inactive pool to meet flow targets and deep drawdowns to near the RO in fall at Blue River would increase shoreline exposure but would have a **negligible** effect on the activation of landslides because only small landslides are mapped around the reservoir. |

| Basin and Project | Summary |
|---|---|
| McKenzie - Cougar | Deep drawdowns to near the RO in fall and spring at Cougar would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate sized mapped landslides that have a history of movement since project construction |
| Middle Fork Willamette - Dexter | No measures that effect landslide formation are proposed at Dexter would increase shoreline exposure, therefore effects are **negligible**. |
| Middle Fork Willamette - Fall Creek | Augmentation from the inactive pool to meet flow targets at Fall Creek would not increase shoreline exposure and would have a **negligible** effect on the activation of landslides |
| Middle Fork Willamette - Hills Creek | Augmentation from the inactive pool to meet flow targets and deep drawdowns to near the RO in fall and spring at Hills Creek would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate mapped landslides that have a history of movement since project construction. |
| Middle Fork Willamette - Lookout Point | Augmentation from the power pool to meet flow targets and deep drawdowns to near the RO in fall and spring at Lookout Point would increase shoreline exposure and would have a **minor** effect on the activation of landslides due to large and moderate sized mapped landslides that do not have a history of movement. |
| Santiam - Big Cliff | No measures that effect landslide formation are proposed for at Big Cliff that would increase shoreline exposure, therefore effects are **negligible**. |
| Santiam - Detroit | Augmentation from the power pool to meet flow targets and deep drawdowns to near the RO in fall at Detroit would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate sized mapped landslides that have a history of movement since project construction |
| Santiam - Foster | No measures that effect landslide formation are proposed at Foster that would increase shoreline exposure, therefore effects are **negligible**. |
| Santiam - Green Peter | Augmentation from the power pool to meet flow targets and deep drawdowns to near the RO in fall and spring at Green Peter would increase shoreline exposure and would have a **minor** effect on the activation of landslides due to large and moderate sized mapped landslides that do not have a history of movement since project completion. |

#### *3.4.2.8 Alternative 4 – Structures-Based Fish Passage Alternative*

##### *3.4.2.8.1 Santiam Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Under Alternative 4, augmenting instream flows by using the power pool (#304) is proposed for Green Peter and Detroit. Due to the moderate-sized landslides that do not have a history of movement mapped in contact with the reservoir, environmental consequences at Green Peter Dam would have minor, indirect, adverse, local effects. Based on the large landslides at Detroit Dam that do have a history of movement since the beginning of dam operations, the environmental effect from this measure is moderate.

**Removal of Geologic Material**

This alternative includes constructing a water temperature control tower (#105) at Detroit and the construction of a structural downstream fish passage (#392) for Foster and Detroit. These structures would likely require small-scale and localized rock excavation. This would have a minor effect on local geology.

##### *3.4.2.8.2 Long Tom Subbasin*

**Activation of Landslides Due to Deep Drawdown**

No measures that reduce the pool below the rule curve, active pool, or draft the reservoir down to the RO are included for Fern Ridge under this alternative.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative.

##### *3.4.2.8.3 McKenzie Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Alternative 4 includes augmenting instream flows by using the power pool (#304) for Cougar and augmenting instream flows by using the inactive pool (#718) for Blue River, both of which result in reservoir drawdowns below the NAA rule curve elevations. Based on the presence of landslides that have exhibited movement since project completion, there is the potential for moderate, indirect, adverse, local effects from landslides along the upstream reservoir rims at Cougar due to augmented instream flows from the power pool (#304). The effects from augmentation of instream flows by using the inactive pool (#718) at Blue River would be negligible because only small landslides are mapped in contact with the reservoir compared to the NAA.

**Removal of Geologic Material**

This alternative includes the construction of a structural downstream fish passage (#392) for Cougar. These structures would likely require small-scale and localized rock excavation, which would have a minor local effect.

*3.4.2.8.4 Middle Fork of the Willamette Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Alternative 4 includes augmenting instream flows by using the power pool (#304) to augment flows at Lookout Point and Hills Creek, which both result in reservoir drawdowns below the NAA rule curve elevations.

At Fall Creek, augmenting instream flows by using the inactive pool (#718) would not result in a change in shoreline exposure compared with the NAA, so the effect of this measure is negligible. Due to the presence of large landslides that do not have a history of movement and an increase in shoreline exposure compared to the NAA, there is the potential for minor, indirect, adverse, local effects at Lookout Point due to augmented instream flows from the power pool (#304). Based on large landslides that have experienced movement since project completion, there is the potential for moderate, indirect, adverse, local effects from landslides with a history of movement along the upstream reservoir rims due the increase in shoreline exposure caused by augmented instream flows from the power pool (#304) at Hills Creek.

**Removal of Geologic Material**

This alternative includes constructing a water temperature control (WTC) tower (#105) at Hills Creek and constructing structural downstream fish passage (#392) at both Lookout Point and Hills Creek which would require small-scale and localized rock excavation. This would have a minor effect on local geology at both projects compared to the NAA.

*3.4.2.8.5 Coast Fork of the Willamette Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Alternative 4 includes augmenting instream flows by using the inactive pool (#718), which results in reservoir drawdowns below the normal rule curve elevations at Cottage Grove and Dorena. Because there are large landslides mapped at Dorena that have no history of movement, this measure would have a minor, indirect, adverse, local effect on landslides. No landslides are mapped around Cottage Grove, so the effect of drawdown would be negligible compared to the NAA.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative is none.

*3.4.2.8.6 Near Term Operations Measures*

See Alternative 2A, Section 0, for description of effects due to the Near-Term Operations Measure.

*3.4.2.8.7 Climate Change*

Climate change would increase the probability of initiation of landslides due to deep drawdown under this alternative by three mechanisms: increasing the annual probability that a deep drawdown would occur, increasing the annual probability that major precipitation events would occur coincident with deep drawdown, and increasing the frequency of wildfires. Under Alternative 4 climate change is likely to enhance landslide risk at Cougar, Detroit, Dorena, Green Peter, Hills Creek, and Lookout Point compared with the NAA.

Due to decreasing future summer and fall inflows, WVS projects may reach their minimum water surface elevations more frequently and sooner in the year, which would increase the duration of shoreline exposure. This would increase the potential for erosion to undercut and destabilize slopes, which could result in an increased risk of slope failure during the next refill/drawdown cycle. Drawdown also may be more rapid to meet downstream minimum flow targets, which would mean a higher pore pressure differential between the slope and atmosphere could occur, increasing the risk of slope failure.

The WVS would likely experience increasing wintertime flow volumes in the future because of larger precipitation events and more precipitation falling as rain instead of snow. Intense rainfall is a triggering event for shallow landslides (Wieczorek, 1996). If large events were to occur coincident with deep drawdowns the exposed shoreline may saturate and cause shallow landslides that progress into larger debris flows and reactivate larger landslides in vulnerable slopes.

Increased variability in the spring rainfall, drier hotter summers, and lower summer baseflow mean that there is more potential for wildfires to impact the reservoir rim. Wildfire can produce a water repellent soil layer that increases overland flow through burnt forested areas (Wieczorek, 1996), and may lead to erosive undercutting of the exposed shoreline and saturation of unvegetated soils, which could lead to slope failure.

*3.4.2.8.8 Summary of Effects of Alternative 4*

**Table 3.4-8. Summary of effects for Geology and Soils under Alternative 4 as compared to the No Action Alternative**

| Basin and Project | Summary |
|---|---|
| Coast Fork Willamette - Cottage Grove | Augmentation from the inactive pool to meet flow targets at Cottage Grove would have a **negligible** effect on the activation of landslides due to no mapped landslides being in connection with the reservoir. |

| Basin and Project | Summary |
|---|---|
| Coast Fork Willamette - Dorena | Augmentation from the inactive pool to meet flow targets at Dorena would increase shoreline exposure and would have a **minor** effect on the activation of landslides due to large and moderate sized mapped landslides that do not have a history of movement. |
| Long Tom - Fern Ridge | No measures that effect landslide formation are proposed for at Fern Ridge that would increase shoreline exposure, therefore effects are **negligible**. |
| McKenzie - Blue River | Augmentation from the inactive pool to meet flow targets at Blue River would increase shoreline exposure but would have a **negligible** effect on the activation of landslides because only small landslides are mapped around the reservoir. |
| McKenzie - Cougar | Augmentation from the power pool to meet flow targets at Cougar would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate sized mapped landslides that have a history of movement since project construction. Construction of a structural downstream passage at Cougar would result in minor local removal of geologic materials. |
| Middle Fork Willamette - Dexter | No measures that effect landslide formation are proposed for at Dexter would increase shoreline exposure, therefore effects are **negligible**. |
| Middle Fork Willamette - Fall Creek | Augmentation from the inactive pool to meet flow targets at Fall Creek would not increase shoreline exposure and would have a **negligible** effect on the activation of landslides |
| Middle Fork Willamette - Hills Creek | Augmentation from the power pool to meet flow targets at Hills Creek would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate sized mapped landslides that have a history of movement since project construction. Construction of a temperature control tower and structural downstream passage at Hills Creek would result in **minor** local removal of geologic materials. |
| Middle Fork Willamette - Lookout Point | Augmentation from the power pool to meet flow targets at Lookout Point would increase shoreline exposure and would have a **minor** effect on the activation of landslides due to large and moderate sized mapped landslides that do not have a history of movement. Construction of a temperature control tower and structural downstream passage at Lookout Point would result in minor local removal of geologic materials. |

| Basin and Project | Summary |
|---|---|
| Santiam - Big Cliff | No measures that effect landslide formation are proposed for at Big Cliff that would increase shoreline exposure, therefore effects are **negligible**. |
| Santiam - Detroit | Augmentation from the power pool to meet flow targets at Detroit would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate mapped landslides that have a history of movement since project construction. Construction of a temperature control tower and structural downstream passage at Detroit would result in **minor** local removal of geologic materials. |
| Santiam - Foster | No measures that effect landslide formation are proposed at Foster that would increase shoreline exposure, therefore effects are **negligible**. Construction of a structural downstream passage at Foster would result in **minor** local removal of geologic materials. |
| Santiam - Green Peter | Augmentation from the power pool to meet flow targets at Green Peter would increase shoreline exposure and would have a **minor** effect on the activation of landslides due to large and moderate sized mapped landslides that do not have a history of movement since project completion. |

#### *3.4.2.9 Alternative 5 - Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

##### *3.4.2.9.1 Santiam Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Augmenting instream flows by using the power pool (#304) is proposed for Green Peter and Detroit under Alternative 5. Deeper fall reservoir drawdowns for fish passage (#40) would allow deep reservoir drawdown to within 25 feet of the RO invert at Green Peter.

Green Peter has moderate-sized landslides that have not experienced movement since project initiation, therefore increased shoreline exposure due to deeper fall reservoir drawdowns for fish passage (#40) and augmented instream flows from the power pool (#304) has some potential to initiate minor, indirect, adverse, local effects from landslides around the reservoir's rim. Based on the moderate-sized landslides at Detroit Dam that have a history of movement since the beginning of dam operations, augmented instream flows from the power pool (#304) has some potential to initiate moderate, indirect, adverse, local effects from landslides around the reservoir's rim compared to the NAA.

**Removal of Geologic Material**

Alternative 5 includes constructing a water temperature control tower (#105) at Detroit and constructing a structural downstream fish passage (#392) for Foster and Detroit. These structures would likely require small-scale and localized rock excavation. This would have a minor direct effect on local geology at both Foster and Detroit compared to the NAA.

*3.4.2.9.2 Long Tom Subbasin*

**Activation of Landslides Due to Deep Drawdown**

No measures that reduce the pool below the rule curve, active pool, or draft the reservoir down to the RO are included for Fern Ridge under this alternative. The effect of this alternative on local geology is none.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative on local geology is none.

*3.4.2.9.3 McKenzie Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Alternative 5 includes augmenting instream flows by using the power pool (#304) for Blue River and augmenting instream flows by using the inactive pool (#718) for Cougar. Both of these measures result in reservoir drawdowns below the normal rule curve elevations. At Cougar deeper fall reservoir drawdowns for fish passage (#40) would allow reservoir drawdown to within 10 feet of the RO invert and spring reservoir drawdown for downstream fish passage (#720) proposes use of the diversion tunnel and drawdown to streambed. Based on the presence of landslides at Cougar that have shown some small-scale movement since project initiation, there is the potential for moderate, indirect, adverse, local effects from landslides along the upstream reservoir rims because of increased shoreline exposure due to deeper fall reservoir drawdowns for fish passage (#40), augmented instream flows from the power pool (#304), and spring reservoir drawdown for downstream fish passage (#720) compared to the NAA. The effects from augmentation of instream flows by using the inactive pool (#718) at Blue River are expected to be negligible because no landslides are mapped in contact with the reservoir compared to the NAA.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative on local geology is none.

#### *3.4.2.9.4 Middle Fork of the Willamette Subbasin*

**Activation of Landslides Due to Deep Drawdown**

Under Alternative 5, augmenting instream flows by using the power pool (#304) is proposed for Lookout Point and Hills Creek and augmenting instream flows by using the inactive pool (#718) is proposed for Fall Creek. Due to the presence of large landslides that do not have a history of movement, there is the potential for minor, indirect, adverse, local effects at Lookout Point due to increased shoreline exposure from augmented instream flows from the power pool (#304). Based on the presence of landslides at Hills Creek that have shown some small-scale movement since project initiation, there is the potential for moderate, indirect, adverse, local, effects from increased shoreline exposure due to augmented instream flows from the power pool (#304) compared to the NAA.

**Removal of Geologic Material**

Alternative 5 includes constructing structural downstream fish passage (#392) at Lookout Point which would require localized rock excavation. This would have a minor direct effect on local geology.

#### *3.4.2.9.5 Coast Fork of the Willamette Subbasin*

**Activation of Landslides Due to Deep Drawdown**

No measures that reduce the pool below the rule curve, active pool, or draft the reservoir down to the RO are included under this alternative. The effect of this alternative is none.

**Removal of Geologic Material**

No measures that would result in excavation of geologic materials are proposed under this alternative. The effect of this alternative is none.

#### *3.4.2.9.6 Near Term Operations Measures*

See Alternative 2A, Section 0, for description of effects due to the Near-Term Operations Measure.

#### *3.4.2.9.7 Climate Change*

Climate change would increase the probability of initiation of landslides due to deep drawdown under this alternative by three mechanisms: increasing the annual probability that a deep drawdown would occur, increasing the annual probability that major precipitation events would occur coincident with deep drawdown, and increasing the frequency of wildfires. Under Alternative 5, climate change is likely to enhance landslide risk at Cougar, Detroit, Green Peter, and Hills Creek compared with the NAA.

Due to decreasing future summer and fall inflows, WVS projects may reach their minimum water surface elevations more frequently and sooner in the year, which would increase the duration of shoreline exposure. This would increase the potential for erosion to undercut and destabilize slopes, which could result in an increased risk of slope failure during the next refill/drawdown cycle. Drawdown also may be more rapid to meet downstream minimum flow targets, which would mean a higher pore pressure differential between the slope and atmosphere could occur, increasing the risk of slope failure.

The WVS would likely experience increasing wintertime flow volumes in the future because of larger precipitation events and more precipitation falling as rain instead of snow. Intense rainfall is a triggering event for shallow landslides (Wieczorek, 1996). If large events were to occur coincident with deep drawdowns the exposed shoreline may saturate and cause shallow landslides that progress into larger debris flows and reactivate larger landslides in vulnerable slopes.

Increased variability in the spring rainfall, drier hotter summers, and lower summer baseflow mean that there is more potential for wildfires to impact the reservoir rim. Wildfire can produce a water repellent soil layer that increases overland flow through burnt forested areas (Wieczorek, 1996), and may lead to erosive undercutting of the exposed shoreline and saturation of unvegetated soils, which could lead to slope failure.

#### *3.4.2.9.8 Summary of Effects of Alternative 5*

**Table 3.4-9. Summary of effects for Geology and Soils under Alternative 5 as compared to the No Action Alternative**

| Basin and Project | Summary |
|---|---|
| Coast Fork Willamette - Cottage Grove | No measures that effect landslide formation are proposed for Cottage Grove that would increase shoreline exposure, therefore effects are **negligible**. |
| Coast Fork Willamette - Dorena | No measures that effect landslide formation are proposed for Dorena that would increase shoreline exposure, therefore effects are **negligible**. |
| Long Tom - Fern Ridge | No measures that effect landslide formation are proposed for Fern Ridge that would increase shoreline exposure, therefore effects are **negligible**. |
| McKenzie - Blue River | Augmentation from the inactive pool to meet flow targets at Blue River would increase shoreline exposure but would have a **negligible** effect on the activation of landslides because only small landslides are mapped around the reservoir. |
| McKenzie - Cougar | Augmentation from the power pool to meet flow targets and deep drawdowns to near the RO in fall at Cougar would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate sized mapped |

| Basin and Project | Summary |
|---|---|
| | landslides that have a history of movement since project construction |
| Middle Fork Willamette - Dexter | No measures that effect landslide formation are proposed for Dexter would increase shoreline exposure, therefore effects are **negligible**. |
| Middle Fork Willamette - Fall Creek | Augmentation from the inactive pool to meet flow targets at Fall Creek would not increase shoreline exposure and would have a **negligible** effect on the activation of landslides |
| Middle Fork Willamette - Hills Creek | Augmentation from the power pool to meet flow targets at Hills Creek would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate sized mapped landslides that have a history of movement since project construction |
| Middle Fork Willamette - Lookout Point | Augmentation from the power pool to meet flow targets at Lookout Point would increase shoreline exposure and would have a **minor** effect on the activation of landslides due to large and moderate mapped landslides that do not have a history of movement. Constructing a structural downstream fish passage at Lookout Point would have a **minor** effect on the removal of geologic materials. |
| Santiam - Big Cliff | No measures that effect landslide formation are proposed for Big Cliff that would increase shoreline exposure, therefore effects are **negligible**. |
| Santiam - Detroit | Augmentation from the power pool to meet flow targets at Detroit would increase shoreline exposure and would have a **moderate** effect on the activation of landslides due to large and moderate mapped landslides that have a history of movement since project construction. Construction of a WTC tower and fish passage structure would have a **minor** effect on removal of geologic material. |
| Santiam - Foster | No measures that effect landslide formation are proposed at Foster that would increase shoreline exposure, therefore effects are **negligible**. |
| Santiam - Green Peter | Augmentation from the power pool to meet flow targets and deep drawdowns to near the RO in fall at Green Peter would increase shoreline exposure and would have a **minor** effect on the activation of landslides due to large and moderate mapped landslides that do not have a history of movement since project completion. |

## 3.5 WATER QUALITY

### 3.5.1 Affected Environment

Water quality consists of chemical and physical properties that are an integral part in determining the health of a waterbody. Regulations and guidelines established to protect U.S. waters and species include the Federal Water Pollution Control Act (1948) which was amended and replaced by to the Clean Water Act (1972), as amended, and Endangered Species Act (1973).

In 2008, the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service issued their respective Willamette Project Biological Opinion (BiOp) (NMFS 2008; USFWS 2008). Listed within the NMFS BiOp are Reasonable and Prudent Actions (RPAs) which address multiple interim and long-term water quality improvement objectives.

The Clean Water Act Section 303(d) requires each State to prepare a list of impaired water bodies that do not meet state water quality standards. Under the State of Oregon Administrative Rules (OAR) 340-041, the Oregon Department of Environmental Quality (ODEQ) implements the Water Quality Standards and Total Maximum Daily Loads (TMDL's) for Oregon waters. USACE was given Designated Management Agency status under the act by the Governor of Oregon. A TMDL is a load allocation of a pollutant implemented to reduce the impairment and meet water quality standards. Water Quality Standards in the state of Oregon are listed for pH, Bacteria, Dissolved Oxygen (DO), Temperature, Total Dissolved Gas (TDG), Total Dissolved Solids, Turbidity, Nuisance Phytoplankton and Toxic Substances.

ODEQ added Willamette Basin rivers and streams to the 303(d) list of impaired waters in 1998, for exceeding standards for biological criteria, temperature, and bacteria. A table adapted from the ODEQ 2022 Integrated Report of impaired water bodies downstream of USACE Willamette dams is listed below with water quality parameters (Table 3.5-1). The temperature criteria is listed as "period" in Table 3.5-1 and is associated with fish life stages, mercury criteria is within the water column and within fish tissue, turbidity is within the water column. In 2021 ODEQ and EPA revised the mercury TMDL criteria for the Willamette Basin (ODEQ 2019).

UWR Chinook and UWR steelhead All Willamette Basin sub-basins and the mainstem Willamette River have TMDL load allocations set by the State for mercury, and nine of the 12 sub-basins have load allocations for temperature and bacteria, dissolved oxygen and turbidity. USACE dams are in six of the 12 sub-basins within the Willamette Basin and TMDL load allocations were set by the State for temperature of water released below these dams. The Annual Willamette Basin Water Quality Reports, from 2009 to present, details implemented water quality measures describing reservoir temperature targets, temperature TMDL's, TDG and other water quality and water supply conditions.

Water quality parameters that will be covered include Temperature, TDG, Harmful Algae Blooms (HABs), Turbidity, and Mercury by sub-basin.

**Table 3.5-1. 303d listed Impaired Waterbodies downstream of the Willamette Valley dams. Adapted from ODEQ 2022 Integrated Report including Willamette Valley TMDL. Please refer to the website for full list of impairments: Department of Environmental Quality : TMDL Program: Willamette Basin : Total Maximum Daily Loads : State of Oregon; https://www.oregon.gov/deq/wq/Pages/epaApprovedIR.aspx**

| Name | Description | Pollutant | period | Parameter category | Rationale | Assessed 2022 | Year Assessed | Year Listed |
|---|---|---|---|---|---|---|---|---|
| Coast Fork Willamette River | Cottage Grove Dam to Row River | Dissolved Oxygen | spawn | 4A | 2018: 5 of 8 samples < 11 mg/L and 95% sat | No | 2018 | 2018 |
| Coast Fork Willamette River | Row River to confluence with Willamette River | Dissolved Oxygen | spawn | 4A | Attaining: 0 total excursions is <= 4 needed to list. 18 total sample dates- Does not meet delisting requirements | Yes | 2022 | 2012 |
| Fall Creek | Fall Creek Dam to confluence with Middle Fork Willamette River | Dissolved Oxygen | Year round | 5 | Impaired: 2 excursions of alternate minimum criteria. 0 valid excursions of 7-mi metric. 0 valid excursions of 30-D metric | Yes | 2022 | 2022 |
| Fall Creek | Fall Creek Dam to confluence with Middle Fork Willamette River | Dissolved Oxygen | spawn | 5 | Impaired- 47 valid excursions of 7-D metric | Yes | 2022 | 2022 |
| Lower Blue River | Blue River Dam to confluence with McKenzie River | Dissolved Oxygen | spawn | 5 | Impaired- 114 valid excursions of 7-D metric | Yes | 2022 | 2022 |
| Middle Fork Willamette River | Salt Creek to North Fork Middle Fork Willamette River | Dissolved Oxygen | spawn | 5 | 2018: 3 of 5 samples < 11 mg/L and 95% sat | No | 2018 | 2018 |
| Middle Fork Willamette River | Hills Creek Dam to Salt Creek | Dissolved Oxygen | spawn | 5 | Attaining: 0 total excursions is <= 2 needed to list.- 11 total sample dates- Does not meet delisting requirements | Yes | 2022 | 2018 |
| Middle Fork Willamette River | Dexter Dam to Lost Creek | Dissolved Oxygen | spawn | 5 | 2018: 4 of 5 samples < 11 mg/L and 95% sat | No | 2018 | 2018 |
| Middle Fork Willamette River | Fall Creek to confluence with Willamette River | Dissolved Oxygen | spawn | 5 | Impaired- 14 valid excursions of 7-D metric | Yes | 2022 | 2012 |
| North Santiam River | Big Cliff Dam to Little North Santiam River | Dissolved Oxygen | spawn | 5 | Impaired- 98 valid excursions of 7-D metric | Yes | 2022 | 2022 |

| Name | Description | Pollutant | period | Parameter category | Rationale | Assessed 2022 | Year Assessed | Year Listed |
|---|---|---|---|---|---|---|---|---|
| South Fork McKenzie River | Cougar Dam to confluence with McKenzie River | Dissolved Oxygen | spawn | 5 | Impaired- 71 valid excursions of 7-D metric | Yes | 2022 | 2022 |
| Willamette River | confluence of Middle Fork Willamette River and Coast Fork Willamette River to Luckiamute River | Dissolved Oxygen | spawn | 5 | Impaired- 12 valid excursions of 7-D metric | Yes | 2022 | 2012 |
| Long Tom River | Fern Ridge Dam to confluence with Willamette River | Turbidity | | 5 | Impaired: 2016: 140 high turbidity days; 2017: 125 high turbidity days; 2016: 23 high turbidity days | Yes | 2022 | 2018 |
| North Santiam River | Little North Santiam River to South Santiam River | Turbidity | | 5 | Impaired: 2019: 35 high turbidity days; 2019: 37 high turbidity days; 2019: 11 high turbidity days; 2019: 59 high turbidity days; 2019: 15 high turbidity days | Yes | 2022 | 2022 |
| Row River | Dorena Dam to confluence with Coast Fork Willamette River | Turbidity | | 5 | Impaired: 2016: 146 high turbidity days; 2017: 163 high turbidity days; 2018: 83 high turbidity days | Yes | 2022 | 2018 |
| Santiam River | confluence of North Santiam River and South Santiam River to confluence with Willamette River | Turbidity | | 5 | Impaired: 2017: 17 high turbidity days; 2019: 66 high turbidity days; 2020: 30 high turbidity days; 2017: 55 high turbidity days; 2019: 50 high turbidity days | Yes | 2022 | 2022 |
| Coast Fork Willamette River | Cottage Grove Dam to Row River | Temperature | Year round | 5 | Impaired: 220 valid excursions of criteria. 36 excursions marked invalid due to air temp exclusion rule | Yes | 2022 | 2018 |
| Coast Fork Willamette River | Row River to confluence with Willamette River | Temperature | Year round | 5 | Record ID: 13052- 2004 Data: [DEQ/SECOR] LASAR 10380 River Mile 11.7: From 6/2/2001 to 9/27/2002, 195 days with 7-day-average maximum > 18 degrees Celsius. [DEQ/SECOR] LASAR 10381 River Mile 18.9: From 6/2/2001 to 9/27/2002, 158 days with 7-day-average maximum > 18 deg | No | 2010 | 2010 |
| Fall Creek | Fall Creek Dam to confluence with Middle Fork Willamette River | Temperature | Year round | 5 | Impaired: 168 valid excursions of criteria. 25 excursions marked invalid due to air temp exclusion rule | Yes | 2022 | 2010 |

| Name | Description | Pollutant | period | Parameter category | Rationale | Assessed 2022 | Year Assessed | Year Listed |
|---|---|---|---|---|---|---|---|---|
| Fall Creek | Fall Creek Dam to confluence with Middle Fork Willamette River | Temperature | spawn | 5 | Impaired: 280 valid excursions of 13° criteria. 4 excursions marked invalid due to air temp exclusion rule- 1367 total results | Yes | 2022 | 2018 |
| Green Peter Lake | Lake/Reservoir Unit | Temperature | Year round | 5 | Record ID: 12952- 2004 Data: [DEQ] LASAR 23805 River Mile 16.2: From 6/11/2000 to 9/16/2000, 56 days with 7-day-average maximum > 18 degrees Celsius. | No | 2010 | 2010 |
| Lower Blue River | Blue River Dam to confluence with McKenzie River | Temperature | Year round | 5 | Impaired: 118 valid excursions of criteria. 2 excursions marked invalid due to air temp exclusion rule | Yes | 2022 | 2018 |
| Lower Blue River | Blue River Dam to confluence with McKenzie River | Temperature | spawn | 5 | Impaired: 161 valid excursions of 13° criteria. 0 excursions marked invalid due to air temp exclusion rule- 1054 total results | Yes | 2022 | 2018 |
| McKenzie River | Lower Blue River to Ennis Creek | Temperature | Year round | 5 | Record ID: 13064- 2004 Data: [DEQ/SECOR] LASAR 26770 River Mile 48.8: From 6/16/2001 to 8/31/2002, 0 days with 7-day-average maximum > 16 degrees Celsius. [DEQ/SECOR] LASAR 26757 River Mile 15: From 7/10/2001 to 8/31/2002, 98 days with 7-day-average maximum > 16 degree | No | 2010 | 2010 |
| McKenzie River | Lower Blue River to Ennis Creek | Temperature | spawn | 5 | Carried forward from previous listing | No | 2010 | 2010 |
| Middle Fork Willamette River | Hills Creek Dam to Salt Creek | Temperature | Year round | 5 | Impaired: 93 valid excursions of criteria. 5 excursions marked invalid due to air temp exclusion rule | Yes | 2022 | 2022 |
| Middle Fork Willamette River | Hills Creek Dam to Salt Creek | Temperature | spawn | 5 | Impaired: 187 valid excursions of 13° criteria. 2 excursions marked invalid due to air temp exclusion rule- 1093 total results | Yes | 2022 | 2022 |
| Middle Fork Willamette River | North Fork Middle Fork Willamette River to Sweeney Creek | Temperature | Year round | 5 | Impaired: 228 valid excursions of criteria. 100 excursions marked invalid due to air temp exclusion rule | Yes | 2022 | 2018 |
| Middle Fork Willamette River | North Fork Middle Fork Willamette River to Sweeney Creek | Temperature | spawn | 5 | Impaired: 155 valid excursions of 13° criteria. 2 excursions marked invalid due to air temp exclusion rule- 1100 total results | Yes | 2022 | 2018 |

| Name | Description | Pollutant | period | Paramete r category | Rationale | Assessed 2022 | Year Assessed | Year Listed |
|---|---|---|---|---|---|---|---|---|
| Middle Fork Willamette River | Dexter Dam to Lost Creek | Temperature | Year round | 5 | Impaired: 368 valid excursions of criteria. 91 excursions marked invalid due to air temp exclusion rule | Yes | 2022 | 2018 |
| Middle Fork Willamette River | Dexter Dam to Lost Creek | Temperature | spawn | 5 | Impaired: 294 valid excursions of 13° criteria. 0 excursions marked invalid due to air temp exclusion rule- 1287 total results | Yes | 2022 | 2018 |
| Middle Fork Willamette River | Fall Creek to confluence with Willamette River | Temperature | Year round | 5 | Impaired: 417 valid excursions of criteria. 110 excursions marked invalid due to air temp exclusion rule | Yes | 2022 | 2018 |
| Middle Fork Willamette River | Fall Creek to confluence with Willamette River | Temperature | spawn | 5 | Impaired: 399 valid excursions of 13° C criteria. 23 excursions marked invalid due to air temp exclusion rule- 1360 total results | Yes | 2022 | 2018 |
| Middle Santiam River | Green Peter Dam to Foster Lake | Temperature | spawn | 5 | Impaired: 31 valid excursions of 13° criteria. 0 excursions marked invalid due to air temp exclusion rule- 978 total results | Yes | 2022 | 2018 |
| North Santiam River | Big Cliff Dam to Little North Santiam River | Temperature | spawn | 5 | Impaired: 11 valid excursions of 13° C criteria. 0 excursions marked invalid due to air temp exclusion rule- 1431 total results | Yes | 2022 | 2010 |
| North Santiam River | Little North Santiam River to South Santiam River | Temperature | Year round | 5 | Impaired: 309 valid excursions of criteria. 121 excursions marked invalid due to air temp exclusion rule | Yes | 2022 | 2010 |
| North Santiam River | Little North Santiam River to South Santiam River | Temperature | spawn | 5 | Impaired: 14 valid excursions of 13° C criteria. 0 excursions marked invalid due to air temp exclusion rule- 88 total results | Yes | 2022 | 2010 |
| Row River | Dorena Dam to confluence with Coast Fork Willamette River | Temperature | Year round | 5 | Impaired: 184 valid excursions of criteria. 30 excursions marked invalid due to air temp exclusion rule | Yes | 2022 | 2010 |
| Santiam River | confluence of North Santiam River and South Santiam River to confluence with Willamette River | Temperature | Year round | 5 | Impaired: 255 valid excursions of criteria. 117 excursions marked invalid due to air temp exclusion rule | Yes | 2022 | 2010 |
| Santiam River | confluence of North Santiam River and South Santiam River | Temperature | spawn | 5 | Impaired: 51 valid excursions of 13° criteria. 0 excursions marked invalid due to air temp exclusion rule- 978 total results | Yes | 2022 | 2010 |

| Name | Description | Pollutant | period | Parameter category | Rationale | Assessed 2022 | Year Assessed | Year Listed |
|---|---|---|---|---|---|---|---|---|
| | to confluence with Willamette River | | | | | | | |
| South Fork McKenzie River | Cougar Dam to confluence with McKenzie River | Temperature | Year round | 5 | Impaired: 90 valid excursions of criteria. 38 excursions marked invalid due to air temp exclusion rule | Yes | 2022 | 2018 |
| South Fork McKenzie River | Cougar Dam to confluence with McKenzie River | Temperature | spawn | 5 | Impaired: 32 valid excursions of 13° criteria. 16 excursions marked invalid due to air temp exclusion rule- 1407 total results | Yes | 2022 | 2010 |
| South Santiam River | Foster Dam to North Santiam River | Temperature | Year round | 5 | Impaired: 16 valid excursions of criteria. 7 excursions marked invalid due to air temp exclusion rule | Yes | 2022 | 2010 |
| South Santiam River | Foster Dam to North Santiam River | Temperature | spawn | 5 | Impaired: 22 valid excursions of 13° C criteria. 2 excursions marked invalid due to air temp exclusion rule- 1346 total results | Yes | 2022 | 2010 |
| Willamette River | confluence of Middle Fork Willamette River and Coast Fork Willamette River to Luckiamute River | Temperature | Year round | 5 | Impaired: 866 valid excursions of criteria. 318 excursions marked invalid due to air temp exclusion rule | Yes | 2022 | 2010 |
| Willamette River | confluence of Middle Fork Willamette River and Coast Fork Willamette River to Luckiamute River | Temperature | spawn | 5 | Impaired: 388 valid excursions of 13° C criteria. 0 excursions marked invalid due to air temp exclusion rule- 2957 total results | Yes | 2022 | 2010 |
| Cottage Grove Lake | Lake/Reservoir Unit | Mercury (total) | | 4A | Record ID: 17029- 2012 Data: [USGS] STATION 14152500 at RM 34.8 for 3 samples from 10/25/2011 to 12/30/2011, 1 of 3 valid samples exceed the 0.012 ug/L criteria. 2004 Data: [DEQ] LASAR 13193 River Mile 31.7: From 6/17/1998 to 10/4/1999, 2 out of 4 samples > applicable | No | 2012 | 2012 |
| Coast Fork Willamette River | Row River to confluence with Willamette River | Methylmercury | | 4A | 2018: Geomean > 0.04 mg/kg (0.454) | No | 2018 | 2012 |
| Cottage Grove Lake | Lake/Reservoir Unit | Methylmercury | | 4A | Record ID: 6773- Previous Data: OSHD Fish Consumption Advisory based on 10% of fish tested exceeding USFDA commercial fish | No | 2012 | 2012 |

| Name | Description | Pollutant | period | Parameter category | Rationale | Assessed 2022 | Year Assessed | Year Listed |
|---|---|---|---|---|---|---|---|---|
| | | | | | standard of methylmercury (1.0 ppm) and a range of 0.22 to 1.79 ppm. | | | |
| Dorena Lake | Lake/Reservoir Unit | Methylmercury | | 4A | Record ID: 6774- Previous Data: Elevated levels measured in fish tissue .37 ppm, Consumption Health Advisory issued 2/25/97. | No | 2012 | 2012 |
| McKenzie River | Ennis Creek to confluence with Willamette River | Methylmercury | | 4A | 2018: Geomean > 0.04 mg/kg (0.278) | No | 2018 | 2012 |
| Middle Fork Willamette River | Fall Creek to confluence with Willamette River | Methylmercury | | 4A | 2018: Geomean > 0.04 mg/kg (0.289) | No | 2018 | 2010 |
| Santiam River | confluence of North Santiam River and South Santiam River to confluence with Willamette River | Methylmercury | | 4A | 2018: Geomean > 0.04 mg/kg (0.284) | No | 2018 | 2012 |
| South Santiam River | Foster Dam to North Santiam River | Methylmercury | | 4A | 2018: Arithmetic mean > 0.04 mg/kg (0.0532) | No | 2018 | 2018 |
| Willamette River | confluence of Middle Fork Willamette River and Coast Fork Willamette River to Luckiamute River | Methylmercury | | 4A | 2018: Geomean > 0.04 mg/kg (0.346) | No | 2018 | 2012 |
| Blue River Lake | Lake/Reservoir Unit | Harmful Algal Blooms | | 5 | Record ID: 23213 | No | 2010 | 2010 |
| Detroit Lake | Lake/Reservoir Unit | Harmful Algal Blooms | | 5 | Record ID: 6243 | No | 2010 | 2010 |
| Dexter Reservoir | Lake/Reservoir Unit | Harmful Algal Blooms | | 5 | Record ID: 23199 | No | 2010 | 2010 |
| Dorena Lake | Lake/Reservoir Unit | Harmful Algal Blooms | | 5 | Record ID: 23200 | No | 2010 | 2010 |
| Fern Ridge Lake | Lake/Reservoir Unit | Harmful Algal Blooms | | 5 | Advisories for 2 or more HABs seasons | Yes | 2022 | 2022 |
| Hills Creek Lake | Lake/Reservoir Unit | Harmful Algal Blooms | | 5 | 2018: Data from: 5/15/2008 - 7/16/2008 | No | 2018 | 2010 |

| Name | Description | Pollutant | period | Paramete r category | Rationale | Assessed 2022 | Year Assessed | Year Listed |
|---|---|---|---|---|---|---|---|---|
| Lookout Point Lake | Lake/Reservoir Unit | Harmful Algal Blooms | | 5 | Record ID: 23204 | No | 2010 | 2010 |

### *3.5.1.1 Temperature*

Downstream water temperatures affected by the dams disrupt fish spawning and rearing life stages because water is too warm in the fall/winter and too cool in the summer/spring (Figure 3.5-1, Figure 3.5-2). In the reservoirs, thermal stratification occurs in summer, with warmer water near the surface and cooler water at the bottom. In the winter a lake may "turnover" meaning surface water will cool to temperatures less than water at the bottom thereby displacing the water at the bottom. Currently, dam operations utilize various outlets and spillways to mix temperatures and provide more normative downstream temperatures.

State and resource agencies have implemented temperature TMDLs and temperature targets throughout the year to coincide with life cycle stages of Endangered Species Act (ESA) listed fish. Currently, ESA-listed fish, such as the Upper Willamette River (UWR) spring Chinook *Oncorhynchus tshawytscha*, UWR winter steelhead *Oncorhynchus mykiss*, and bull trout *Salvelinus confluentus* have been identified in the Willamette sub-basins (Oregon Chub de-listed in 2015) (USACE 2020a).

Construction of the Willamette Valley Project dams have disrupted the natural thermal and flow regimes of the rivers (Gregory et al, 2007). The water temperatures below Willamette Valley dams have been identified as one of the limiting factors preventing the recovery of UWR spring Chinook salmon and UWR steelhead (USACE 2000; Taylor et al. 2007; Angilletta et al 2008; NMFS 2008; ODFW and NMFS 2011). Water temperatures are monitored by U.S. Army Corps of Engineers (USACE)-funded U.S. Geological Survey (USGS) gages that may be located upstream (inflow) and downstream (outflow) of a project.

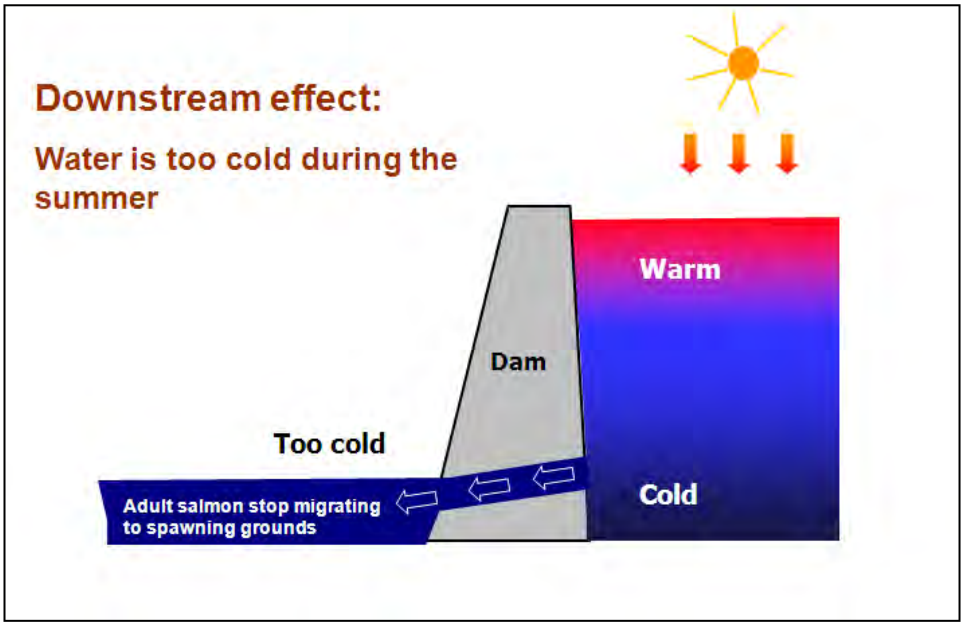



**Figure 3.5-1. Schematic Showing the Influence of Typical Dam Operations on Downstream Water Temperatures During the Conservation Season.** ***USACE, Willamette Fish Operations Plan 2020.***

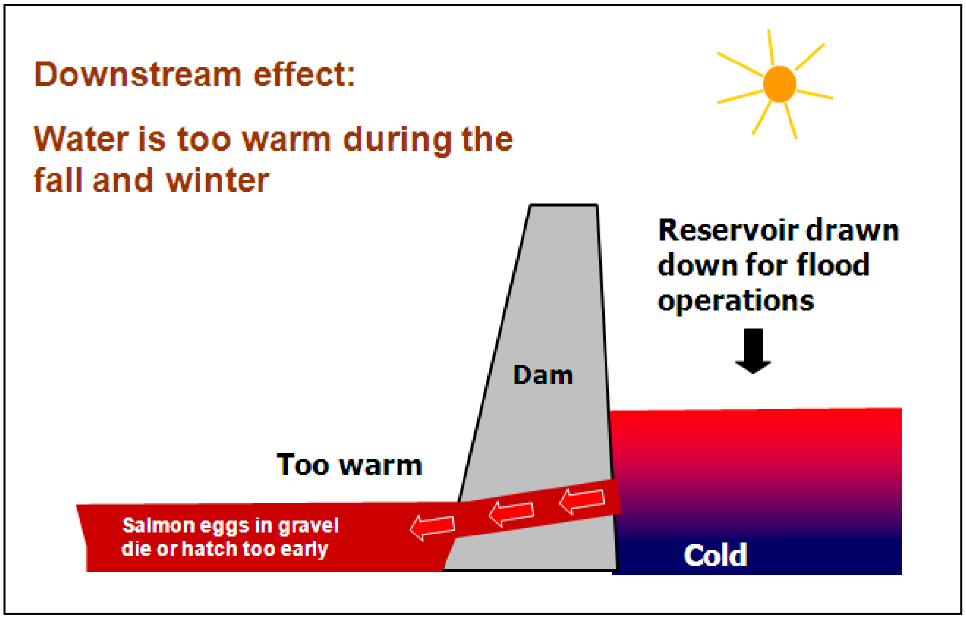



**Figure 3.5-2. Schematic Showing the Influence of Typical Dam Operations on Downstream Water Temperatures During Reservoir Drawdown for Flood Damage Reduction. *USACE, Willamette Fish Operations Plan 2020.***

*3.5.1.1.1 North Santiam Sub-basin*

Detroit Reservoir is a warm monomictic lake that thermally stratifies during the spring, summer and fall months. From June through mid-September the dam provides interim water temperature management downstream using a blend of releases from the spillway, regulating outlets and turbines. During the summer months, the upper layer of water warms due to radiative heating. Water is much cooler near the regulating outlets. The real-time reservoir temperature thermistor string can be accessed through the USACE public website (USACE 2022). The thermistor string data measures the reservoir's thermal stratification throughout the year and helps to inform temperature management operations.

The blending of the two water layers provides downstream temperature control. Water quality considerations shape operation of the reservoirs unless the system is being operated for Flood Risk. USACE-funded USGS gages for monitoring temperature are located above and below Detroit Reservoir for temperature and TDG monitoring (Figure 3.5-3). The State TMDL temperature targets for waters downstream of the Detroit and Big Cliff Dams (Table 3.5-1) were developed with basin experts in 2006. The State also established sub-basin Resource Agency (RA) working groups with specialists from ODFW, ODEQ, NMFS, USFWS and others. The RA's consider various factors like estimated fish emergence timing and spawning time variability, to generate yearly targets as shown in (Table 3.5-1).

Water of varying temperatures released from Detroit Dam mix in Big Cliff Reservoir. A gage is located 0.75 miles below Big Cliff Reservoir near Niagara, Oregon which is the compliance point for water temperature releases from both of the dams. In a typical year, water temperature targets are met during the summer and early fall months, but trend higher than targets in the late fall and early winter (Figure 3.5-4). Outflow temperatures are very close to the TMDL temperature targets, except for October and November (Figure 3.5-5; Figure 3.5-6). This is because Detroit Reservoir is a large body of water and takes longer to warm in the spring and cool in the fall as compared to unregulated river systems. Therefore, a thermal lag is produced resulting in late fall/early winter water temperature objectives not being met. It is not until mid-winter that the reservoir loses all heat gained from the summer season and downstream water temperatures are again achieved.

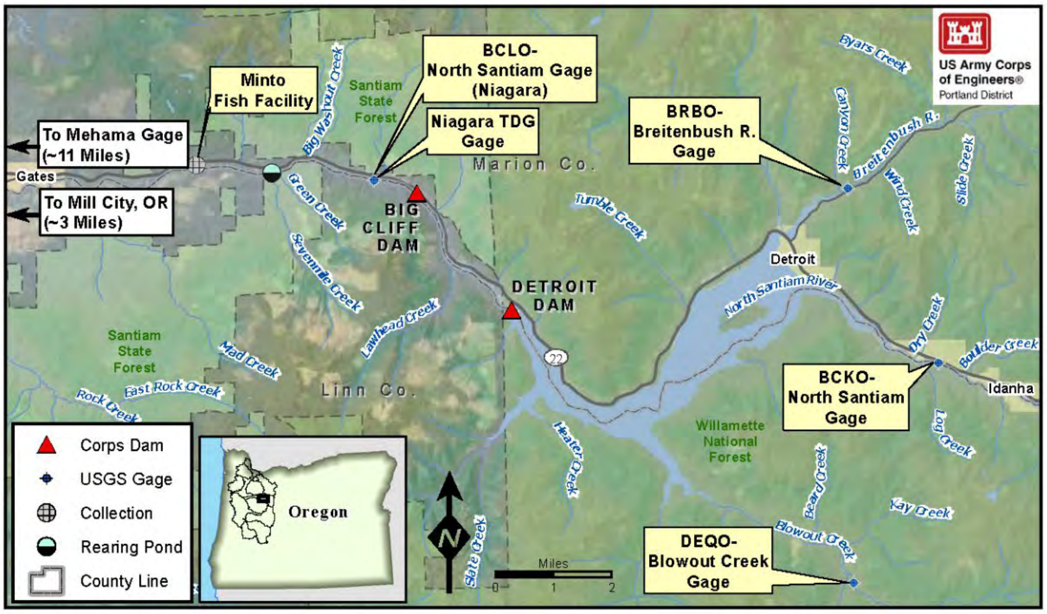



**Figure 3.5-3. Water Temperature USGS Gage Locations: Upstream of Detroit Reservoir on the Breitenbush and North Santiam Rivers and Blowout Creek, and Downstream from Big Cliff Dam to the Minto Fish Facility. USGS Data: http://or.water.usgs.gov/cgi-bin/grapher/table_setup.pl**

**Table 3.5-2. Detroit / Big Cliff Dams Downstream Water Temperature 2020 Resource Agency Targets (Daily Average)* and ODEQ's 2006 TMDL Targets (Seven-Day Average).**

| Month | Current RA Target Temperature Range Maximum / Minimum °F * | | Prior RA Target Temperature Range Maximum / Minimum °F | | ODEQ 2006 TMDL Target Temperatures °F |
|---|---|---|---|---|---|
| January | 42 | 38 | 40.1 | 40.1 | No Allocation Needed |
| February | 42 | 38 | 42.1 | 41.0 | |
| March | 44 | 42 | 42.1 | 41.0 | |
| April | 46 | 42 | 45.1 | 43.2 | 41.7 |
| May | 50 | 46 | 49.1 | 46.0 | 45.1 |
| June | 54 | 48 | 56.1 | 51.1 | 49.5 |
| July | 55 | 52 | 61.2 | 54.1 | 55.0 |

| Month | Current RA Target Temperature Range Maximum / Minimum °F * | | Prior RA Target Temperature Range Maximum / Minimum °F | | ODEQ 2006 TMDL Target Temperatures °F |
|---|---|---|---|---|---|
| August | 55 | 52 | 60.3 | 54.1 | 55.0 |
| September | 54 | 48 | 56.1 | 52.3 | 51.6 |
| October | 52 | 46 | <50.0 | <50.0 | 45.9 |
| November | 46 | 42 | <50.0 | <50.0 | 45.9 |
| December | 46 | 41 | 41.0 | 41.0 | No Allocation Needed |

*Daily average 2020 RA target temperatures proposed by ODFW (2017) and approved in 2017 and 2018 by the North Santiam Temperature task group (USACE, BPA, ODFW, NMFS, USFWS and ODEQ) for downstream of the Detroit and Big Cliff Dams. On July 20, 2018, the maximum 2018 RA targets were revised to 60 °F through August.

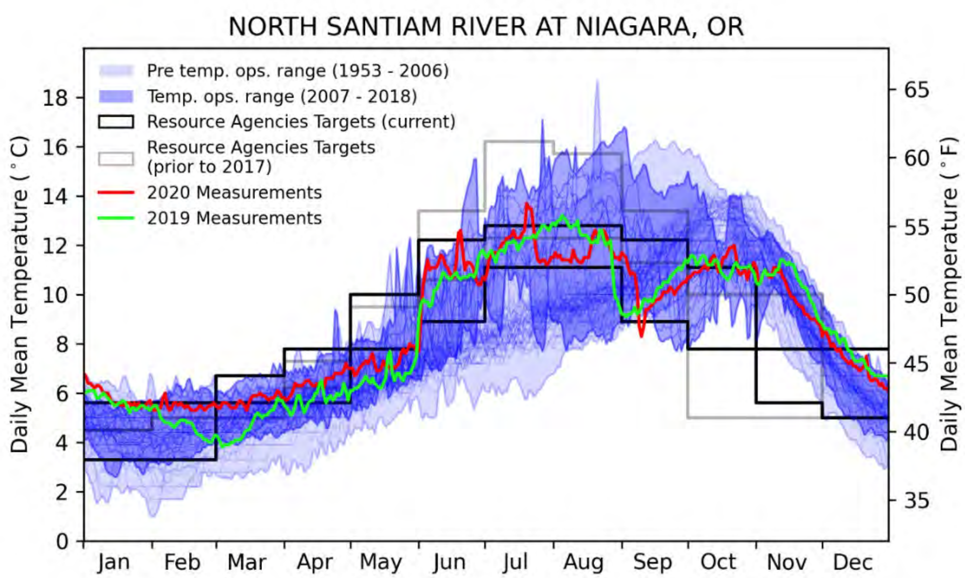



**Figure 3.5-4. Detroit / Big Cliff Reservoirs Daily Mean 2019 and 2020 Outflow Temperatures compared to the 2019 and Prior to 2017 Resource Agencies Target Temperatures and Temperature Ranges before (1953 - 2006) and during (2007 - 2018) Temperature Control Operation Years.**

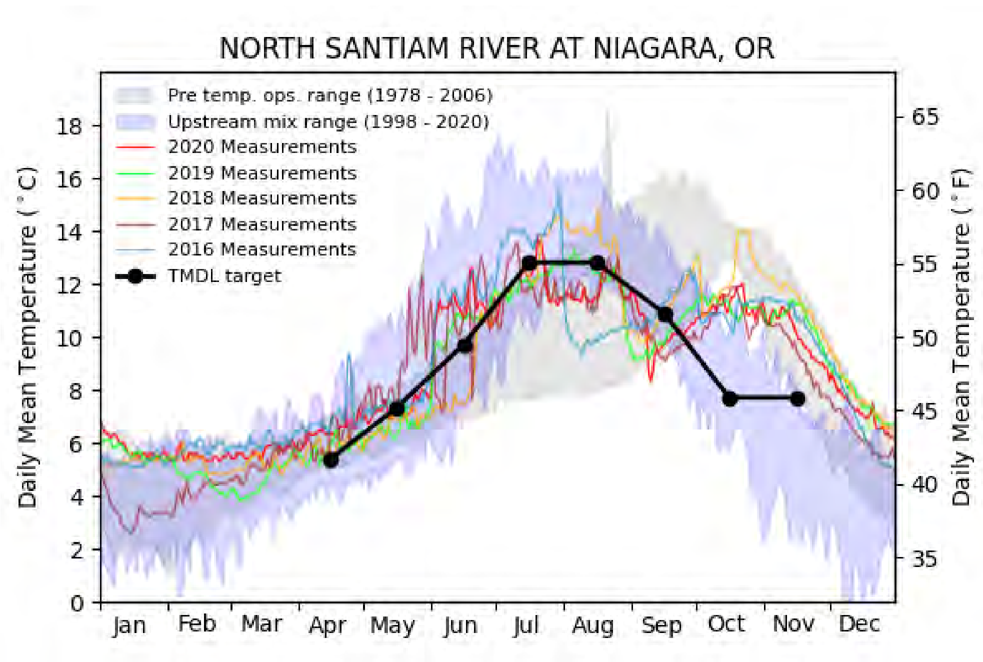



**Figure 3.5-5. Detroit / Big Cliff Reservoirs Daily Mean Outflow Temperatures during Temperature Control Operation Years (2016 - 2020) Measured in the North Santiam River compared to Upstream Mix Range (1998 - 2020), Pre-Temperature Operations Range (1978 - 2006), and Oregon Department of Environmental Quality (ODEQ) Total Maximum Daily Load (TMDL) Monthly Median Target Temperatures.**

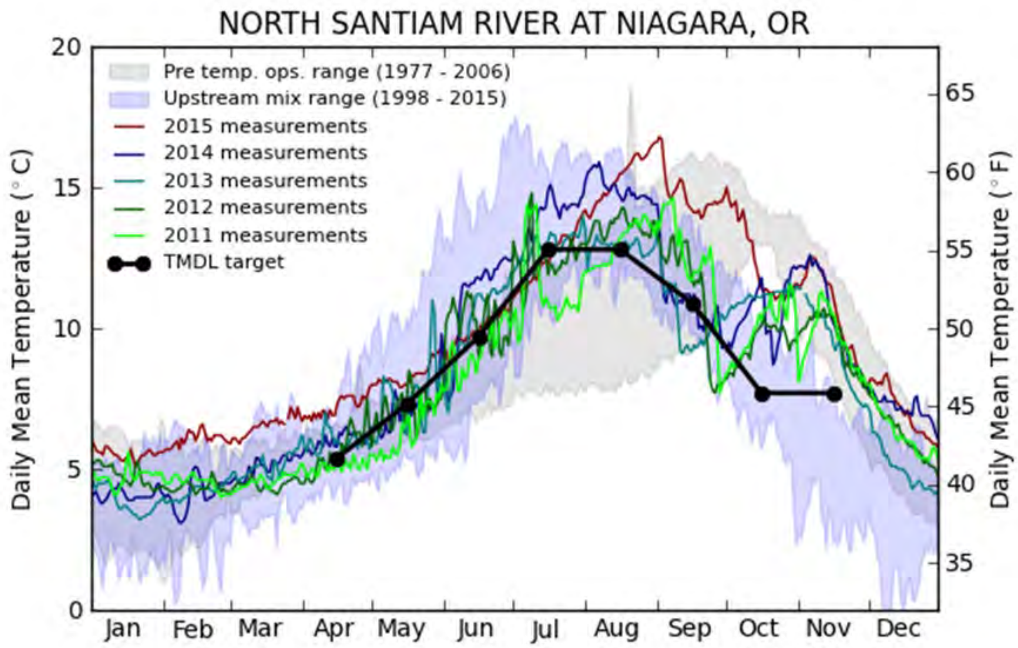



**Figure 3.5-6. Detroit/Big Cliff Reservoirs Daily Mean Outflow Temperatures during Temperature Control Operation Years (2011 – 2015) Measured in the North Santiam River Compared to Upstream Mix Range (1998 – 2015), Pre-Temperature Operations Range (1977-2006), and ODEQ's TMDL Monthly Median Target Temperatures.**

*3.5.1.1.2 South Santiam Sub-basin*

The NMFS 2008 Biological Opinion considers elevated water temperatures caused by dam operations a primary limiting factor for the egg/emergence component of the UWR spring Chinook salmon life stages in the South Santiam River due to premature hatching and emergency (NMFS 2008). Water temperatures can also affect other life stages including upstream migration of UWR spring Chinook salmon and UWR steelhead (USACE 2018b). There are no annual interim temperature control operations at Green Peter Reservoir.

In late-May 2020, a special study released warm water from Green Peter to increase temperatures and trigger a biological response for UWR spring Chinook salmon at the Foster Adult Fish Facility (AFF) ladder (USACE 2020b). Water temperatures increased by 4-5°F over a three-week period and high UWR spring Chinook salmon returns and collections at the AFF were observed. Additionally, there was an outage of an auxiliary water supply (AWS) pump during this period. The AWS acts to recirculate cool turbine water near the entrance of the Foster fish ladder. The outage also improved temperatures prompting an upstream migration response from fish in the tailrace (Figure 3.5-7). The results of the study indicated improved temperatures were needed to better operate the AFF at Foster.

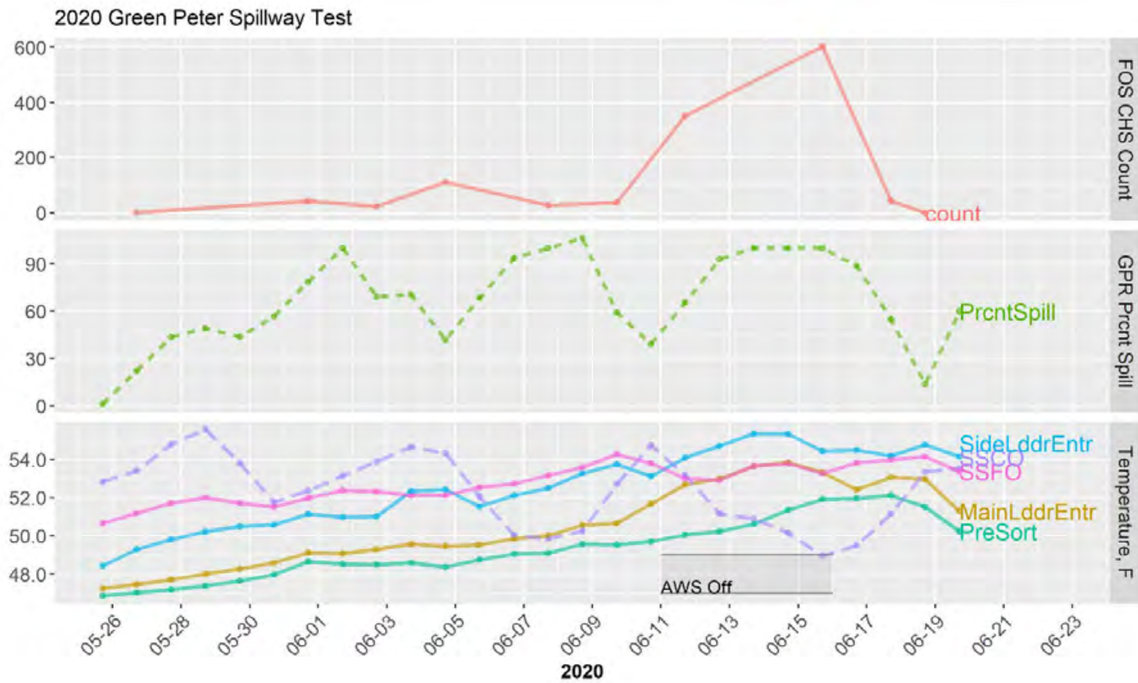



**Figure 3.5-7. 2020 Foster Fish Spring Chinook collection, Green Peter spill operation (percent of total flow), and Foster fish ladder water temperatures May 26 to June 16, 2020. Abbreviation definitions: FOS CHS Count (Foster AFF Chinook Return Fish Count; GPR Prcnt Spill (Green Peter Percent spillway flow as a percentage); SideLddrEntr (Water temperature at the entrance to the AFF on the Foster Spillway side); SSCO (Water temperature at South Santiam River below Cascadia, OR; SSFO (Water temperature at South Santiam River near Foster; MainLddrEntr (Water temperature at the main entrance to the AFF near penstock outfall; PreSort (Water temperature in the AFF fish ladder above the entrance, near holding tank).**

Currently there are three USACE-funded USGS gages that are located at Middle Santiam River upstream of Green Peter Reservoir, Quartzville Creek upstream of Green Peter Reservoir, and Middle Santiam downstream of Green Peter Reservoir (Figure 3.5-8). North Santiam and McKenzie Resource Agency (RA) utilized the targets developed for the for the South Santiam, as targets for this portion of the river have not been developed (Table 3.5-3). However, the South Santiam sub-basin has warmer upstream and cooler downstream temperatures as compared to the North Santiam. Historically, Green Peter temperatures meet RA targets and temperature TMDLs from February to May and tend to be cooler from June to September. Then from October to December temperatures are above the target (Figure 3.5-9 – 3.5-11). In-reservoir temperature thermistor strings were deployed in 2010 and continue to collect data and inform reservoir operations (USACE 2022).

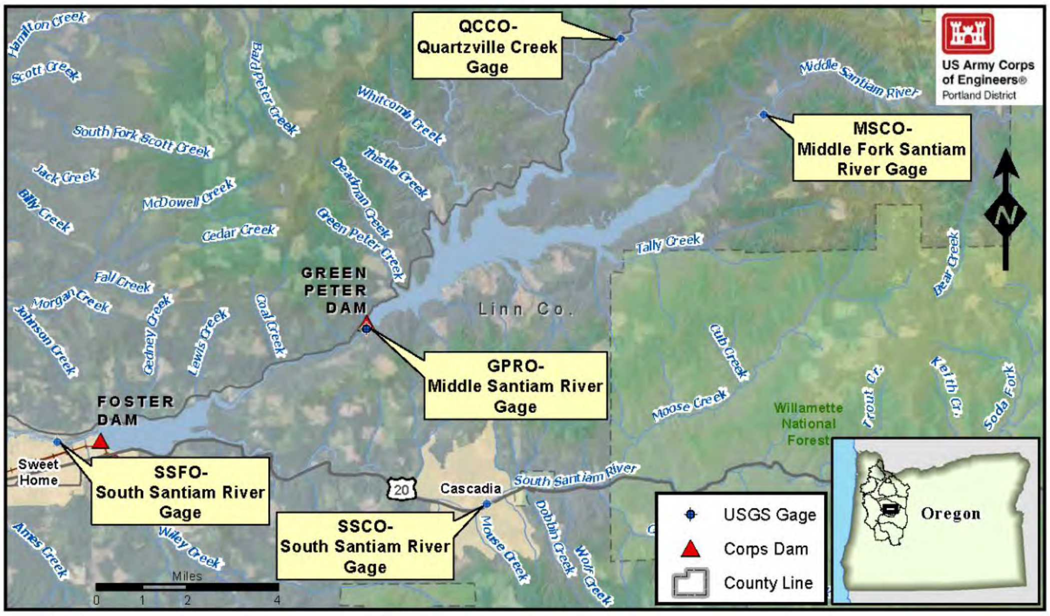



**Figure 3.5-8. Water Temperature USGS Gage Locations: Upstream of Green Peter Reservoir on the Quartzville Creek and the Middle Santiam River; Upstream of Foster Reservoir on South Santiam River; and Downstream of Green Peter and Foster Dams. USGS Data: http://or.water.usgs.gov/cgi-bin/grapher/table_setup.pl**

**Table 3.5-3. Green Peter and Foster Dams Downstream Water Temperature Targets from Resource Agencies (Daily Average)* and ODEQ's 2006 TMDL Targets (Seven-Day Average).**

| Month | RA Target Temperature Range Maximum / Minimum °F* | | ODEQ 2006 TMDL Target Temperatures °F |
|---|---|---|---|
| January | 40.1 | 40.1 | No Allocation Needed |
| February | 42.1 | 41.0 | |
| March | 42.1 | 41.0 | |
| April | 45.1 | 43.2 | 43.0 |
| May | 49.1 | 46.0 | 46.8 |
| June | 56.1 | 51.1 | 54.3 |
| July | 61.2 | 54.1 | 65.1 |
| August | 60.3 | 54.1 | 64.4 |
| September | 56.1 | 52.3 | 59.9 |
| October | <50.0 | <50.0 | 54.7 |
| November | <50.0 | <50.0 | 54.7 |
| December | 41.0 | 41.0 | No Allocation Needed |

*Daily average target temperatures originally developed by the resource agencies (NMFS, USFWS, ODFW) for the McKenzie River below Cougar Dam (October and November slightly modified for the North / South Santiam River).

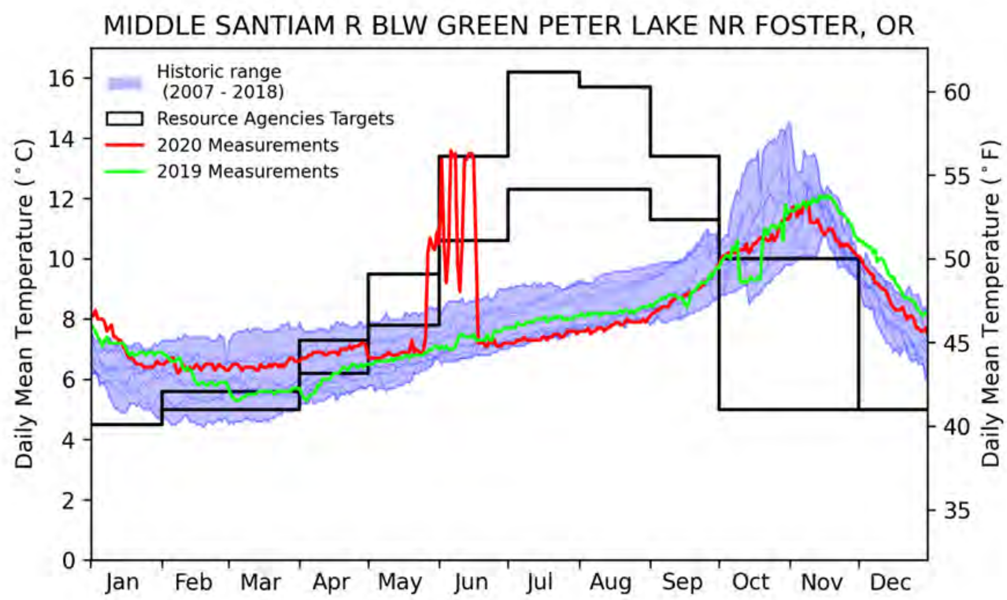



**Figure 3.5-9. Middle Santiam River Below Green Peter Lake near Foster, OR. Green Peter Reservoir Daily Mean 2019 and 2020 Outflow Temperatures compared to Resource Agencies Target Temperatures and Historical Temperature Ranges during 2007 - 2018.**

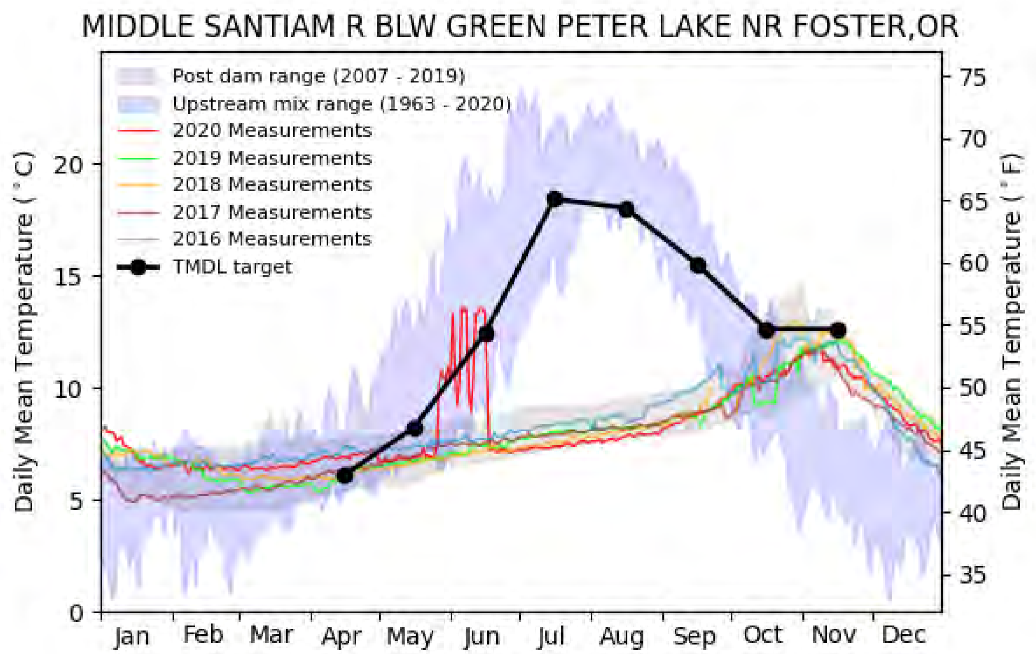



**Figure 3.5-10. Middle Santiam River Below Green Peter Lake near Foster, OR. Green Peter Reservoir Daily Mean Outflow Temperatures (2016 - 2020) Measured in the Middle Santiam River compared to Upstream Mix Range (1963 - 2020), Post Dam Range (2007 - 2019), and Oregon Department of Environmental Quality (ODEQ)'s Total Maximum Daily Load (TMDL) Monthly Median Target Temperatures.**

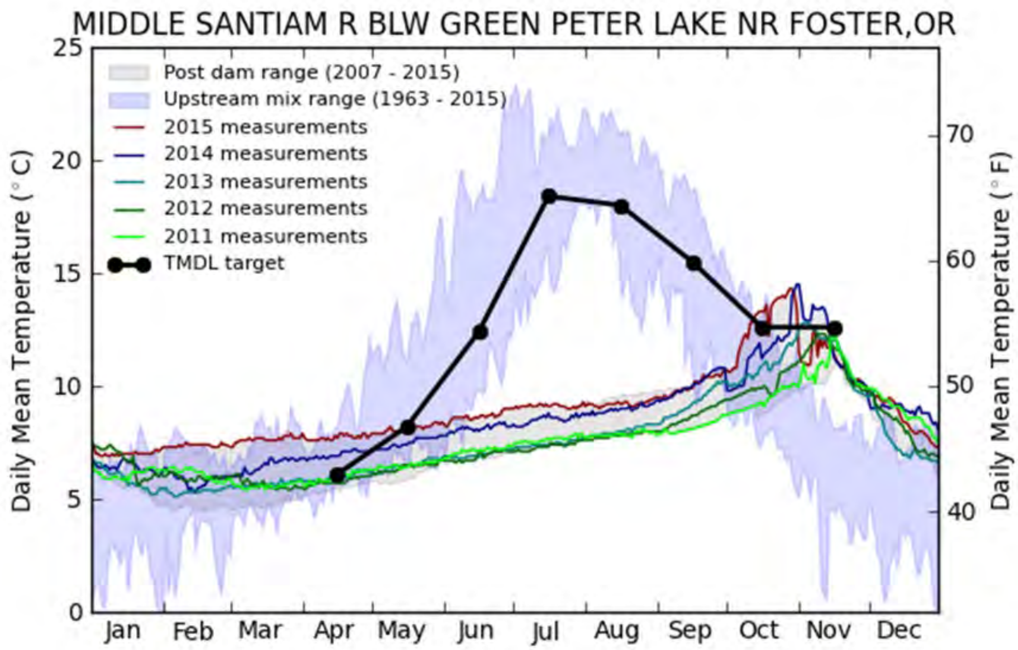



**Figure 3.5-11. Middle Santiam River Below Green Peter Lake near Foster, OR. Green Peter Reservoir Daily Mean Outflow Temperatures (2011 – 2015). Measured in the Middle Santiam River Compared to Upstream Mix Range (1963 – 2015), Post Dam Range (2007-2015), and ODEQ's TMDL Monthly Median Target Temperatures.**

Foster Reservoir is a re-regulating dam and smaller lake as compared to Green Peter Reservoir. Generally unregulated flow from the South Santiam River above Foster provides warmer water and Green Peter Reservoir provides cooler water from the powerhouse discharge. As such, Foster water temperatures stratify in the late Spring and Summer. The current Foster fish passage facility was modified in 2014 in response to the NMFS 2008 BiOp. As previous discussed in this section research in 2017 determined that water temperature from the AFF ladder entrance is too cold compared to historic or ambient river temperatures to attract UWR spring Chinook salmon from May through June, which delays collection and passage (Keefer et al. 2018).

Interim water temperature management operations are currently being conducted to improve water temperatures for upstream fish migration, attraction to the adult fish ladder, and the Foster Fish Facility. The operation uses the Foster Fish Weir to skim warm water off the surface of Foster Reservoir for release downstream. The USACE-funded USGS gages are located on the South Santiam River near the town of Cascadia and South Santiam River downstream of Foster Reservoir (Figure 3.5-8). These gages are used to monitor water temperature as well as other water quality parameters.

Foster temperatures are typically in range of the RA targets and temperature TMDLs from February through June and October through November, and lower from July until September (Figures 3.5-12 – 3.5-14), hence the need for temperature management operations.

In-reservoir thermistor strings were deployed in 2010 and continue to collect data which provides information on the thermal stratification of the reservoir (USACE 2022). The data provided by the gages are being used for water quality modeling efforts utilizing CE-QUAL-W2 to inform operational temperature management plans (USACE 2018b).

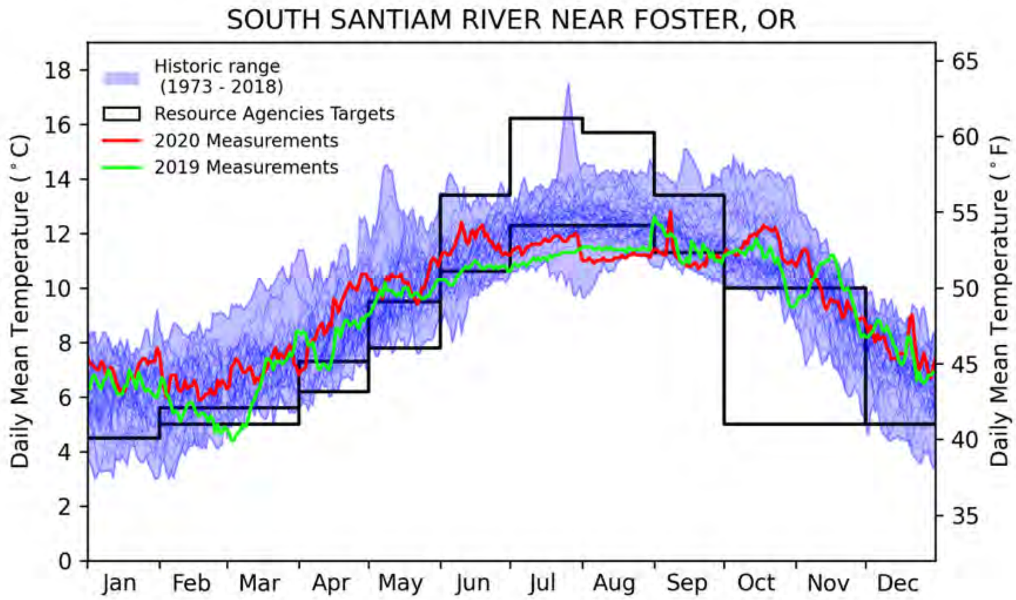



**Figure 3.5-12. South Santiam River near Foster. OR. Foster Reservoir Daily Mean 2019 and 2020 Outflow Temperatures compared to Resource Agencies Target Temperatures and Historical Temperature Ranges during 1973 - 2018.**

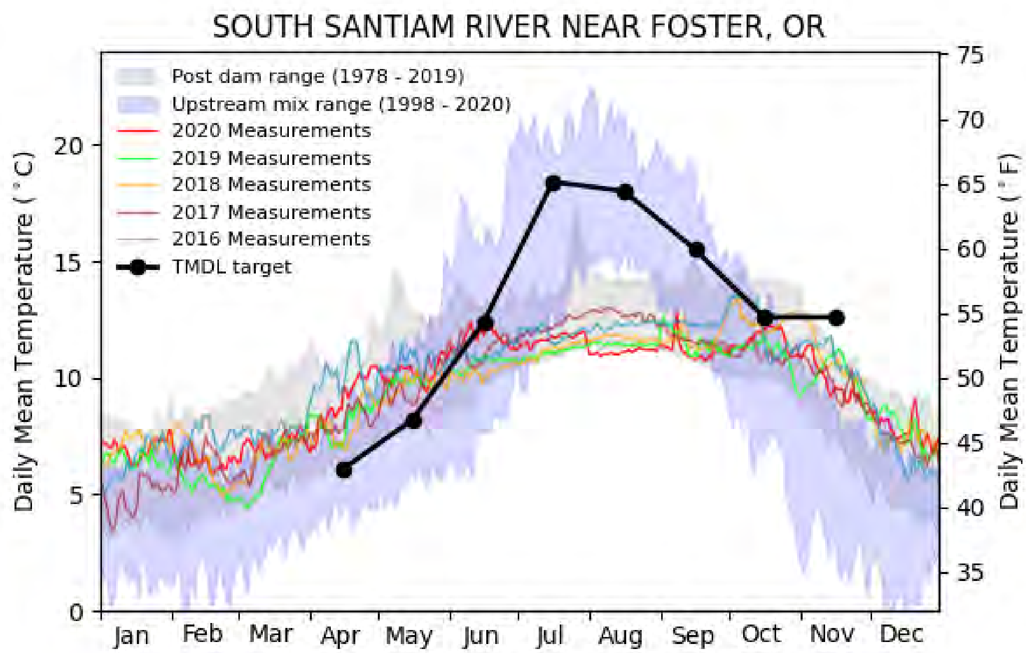



**Figure 3.5-13. South Santiam River near Foster, OR. Foster Reservoir Daily Mean Outflow Temperatures (2016 2020) Measured in the South Santiam River (near Cascadia) compared to Upstream Mix Range (1998 - 2020), Post Dam Range (1978 - 2019), and Oregon Department of Environmental Quality (ODEQ)'s Total Maximum Daily Load (TMDL) Monthly Median Target Temperatures.**

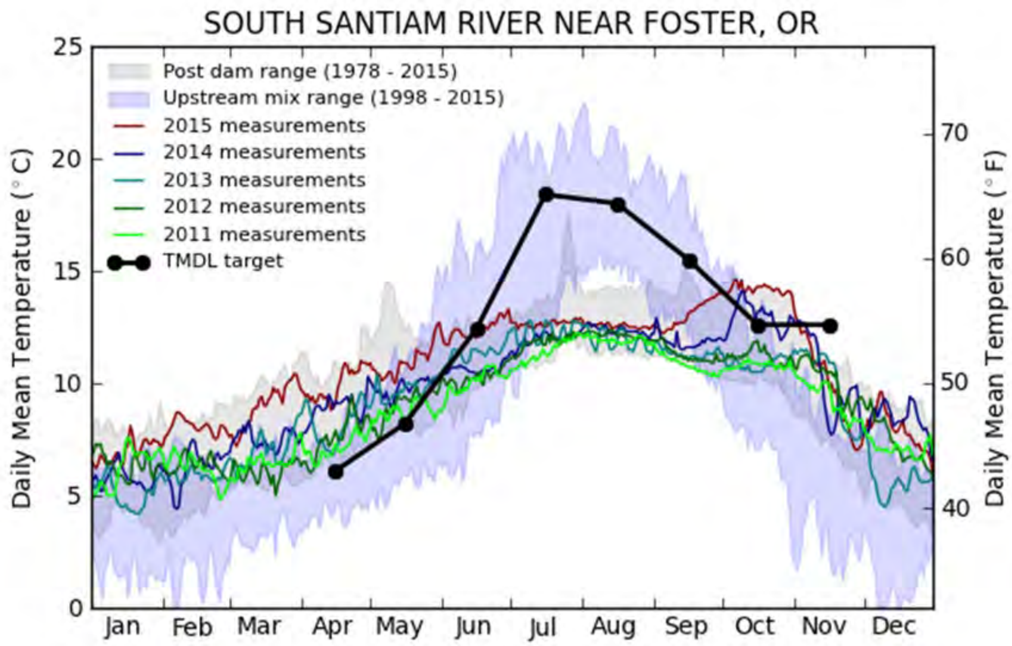



**Figure 3.5-14. South Santiam River near Foster,OR. Foster Reservoir Daily Mean Outflow Temperatures (2011 – 2015) Measured in the South Santiam River (near Cascadia) Compared to Upstream Mix Range (1998 – 2015), Post Dam Range (1978-2015), and ODEQ's TMDL Monthly Median Target Temperatures.**

#### *3.5.1.1.3 McKenzie Sub-basin*

At Cougar Reservoir, the WTC enables the USACE to manage water elevations to regulate downstream temperatures for ESA listed species. USACE-funded USGS temperature gages are located upstream and downstream of the reservoir (Table 3.5-15). The data is available on the USGS' public website (https://or.water.usgs.gov/cgi-bin/grapher/table_setup.pl). There are no temperature management capabilities at Blue River Dam, as there is one set of regulating outlets and spillway. Temperature gages are located upstream and downstream of the dam, which are USACE-funded USGS gages (Figure 3.5-16).

Resource agency temperature targets were developed for Cougar and Blue River Dams (Table 3.5-4). McKenzie River estimated fish emergence times, which are generated yearly based on spawning time variability are also considered. Since 2005, the outflow water temperatures have generally met the RA targets utilizing the WTC at Cougar Reservoir as compared to pre-temperature-control-tower results (Figure 3.5-17). Outflow temperatures are closest to the TMDLs from April through June (Figure 3.5-18; Figure 3.5-19). Temperature thermistor strings are deployed in Cougar Reservoir and collect thermal stratification data. The real-time reservoir temperature thermistor string can be accessed through the USACE public website (USACE 2022). The thermistor string data measures the reservoir's thermal stratification throughout the year and helps to inform temperature management operations. Temperature thermistor strings are not deployed in Blue River reservoir. Historically, Blue River outflow water temperatures are nearest to the RA Targets and TMDLs from February through May and warmer from August through November (Figure 3.5-20 – 3.5-22).

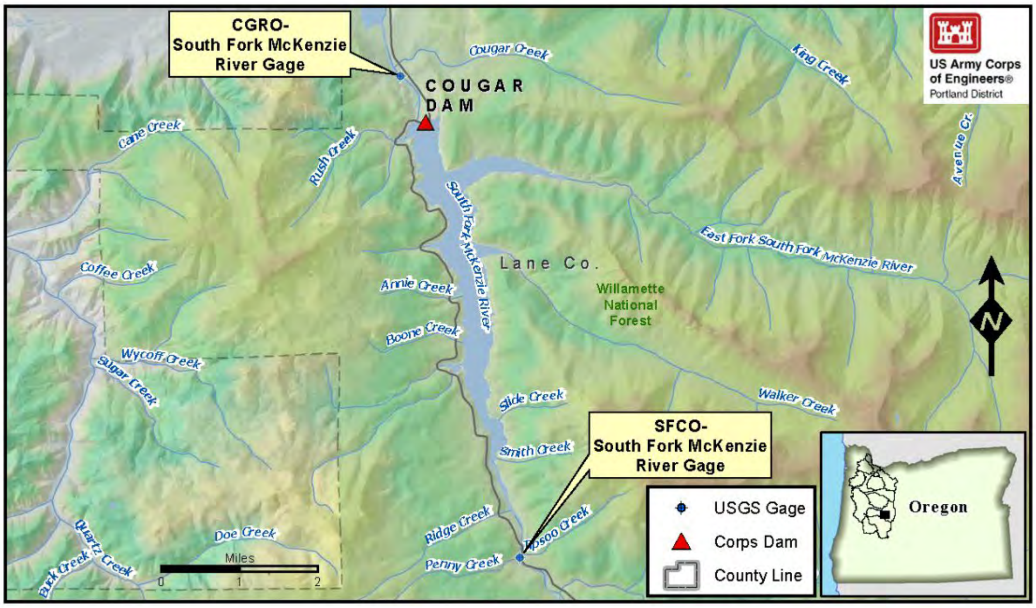



**Figure 3.5-15. Water Temperature USGS Gage Locations : Upstream and Downstream of Cougar Dam and Reservoir on South Fork of McKenzie River. Total Dissolved Gas (TDG) also Collected Downstream. USGS Data: http://or.water.usgs.gov/cgi-bin/grapher/table_setup.pl**

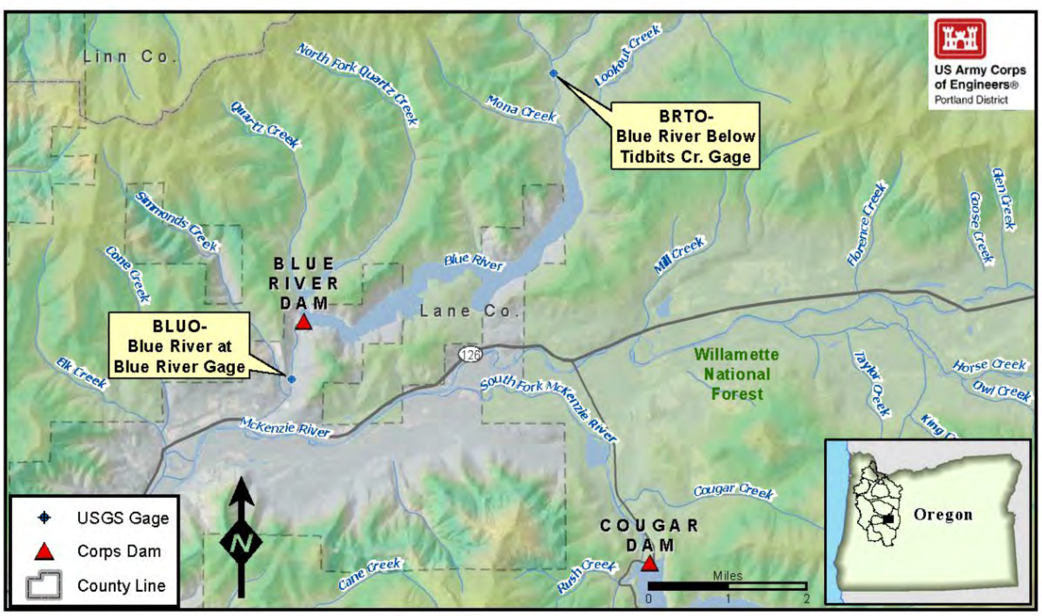



**Figure 3.5-16. Water Temperature USGS Gage Locations : Upstream and Downstream of Blue River and Reservoir on South Fork of McKenzie River. USGS Data: http://or.water.usgs.gov/cgi-bin/grapher/table_setup.pl**

**Table 3.5-4. Cougar Dam Downstream Water Temperature Targets from Resource Agencies (Daily Average)* and Cougar and Blue River Dams ODEQ's 2006 TMDL Targets (Seven-Day Average).**

| Month | RA Target Temperature Range Maximum / Minimum °F* | | ODEQ 2006 TMDL Target Temperatures °F | |
|---|---|---|---|---|
| | | | Cougar | Blue River |
| January | 40.1 | 40.1 | No Allocation Needed | No Allocation Needed |
| February | 42.1 | 41.0 | | |
| March | 42.1 | 41.0 | | |
| April | 45.1 | 43.2 | 41.9 | 41.9 |
| May | 49.1 | 46.0 | 45.9 | 45.7 |
| June | 56.1 | 51.1 | 50.0 | 49.8 |
| July | 61.2 | 54.1 | 53.1 | 52.2 |
| August | 60.3 | 54.1 | 51.6 | 51.1 |
| September | 56.1 | 52.3 | 49.1 | 49.1 |
| October | 49.1 | 47.1 | 45.0 | 45.0 |
| November | 44.1 | 43.2 | 45.0 | 45.0 |
| December | 41.0 | 41.0 | No Allocation Needed | No Allocation Needed |

*Daily average target temperatures developed in 1984 by the resource agencies (NMFS, USFWS, ODFW) for the McKenzie River below Cougar Dam.

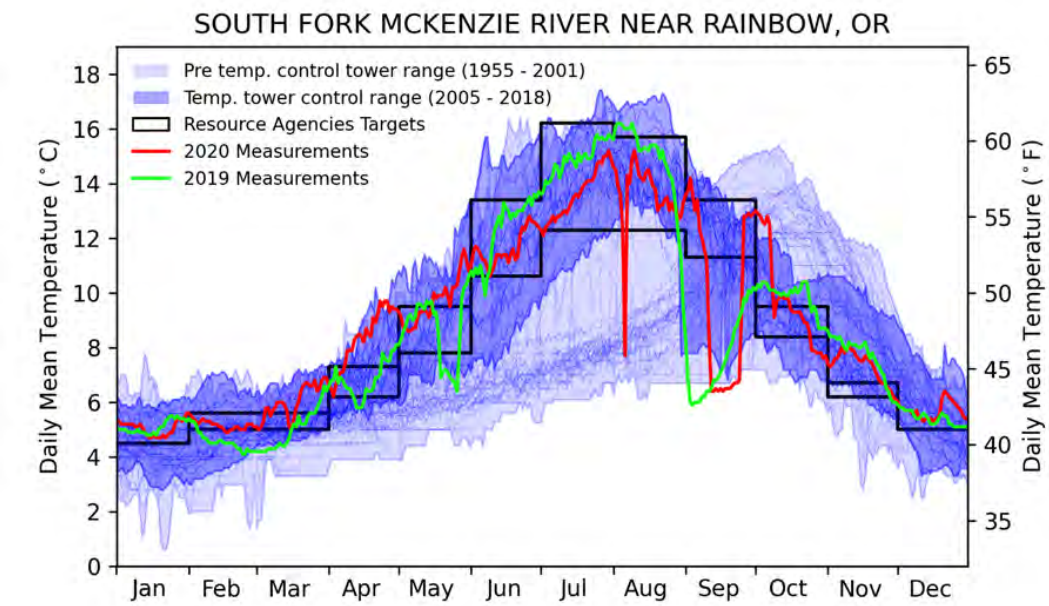



**Figure 3.5-17. South Fork McKenzie River near Rainbow, OR. Cougar Reservoir Daily Mean 2019 and 2020 Outflow Temperatures compared to Resource Agencies Target Temperatures and Temperature Ranges before (1955 - 2001) and during (2005 - 2018) Temperature Tower Operation Years.**

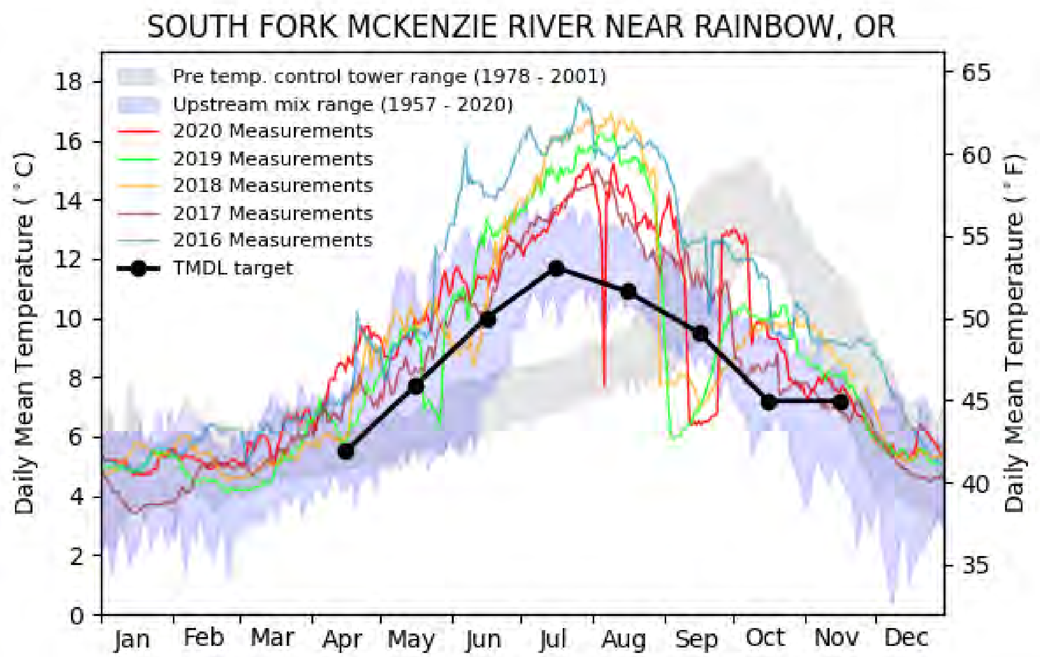



**Figure 3.5-18. South Fork McKenzie River near Rainbow, OR. Cougar Reservoir Daily Mean Outflow Temperatures during Temperature Control Tower Performance Years (2016 - 2020) Measured in the South Fork McKenzie River compared to Upstream Mix Range (1957 - 2020), Pre-Temperature Control Tower Range (1978 - 2001), and Oregon Department of Environmental Quality (ODEQ)'s Total Maximum Daily Load (TMDL) Monthly Median Target Temperatures.**

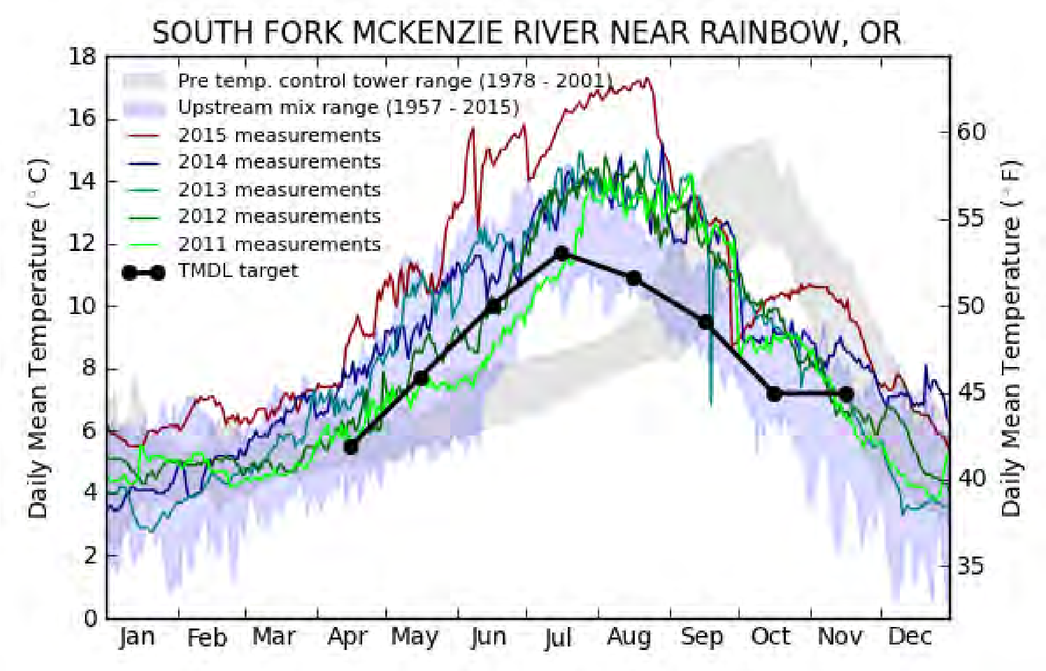



**Figure 3.5-19. South Fork McKenzie River near Rainbow, OR. Cougar Reservoir Daily Mean Outflow Temperatures during Temperature Control Tower Performance Years (2011 – 2015) Measured in the South Fork McKenzie River Compared to Upstream Mix Range (1957 – 2015), Pre-Temperature Control Tower Range (1978-2001), and ODEQ's TMDL Monthly Median Target Temperatures.**

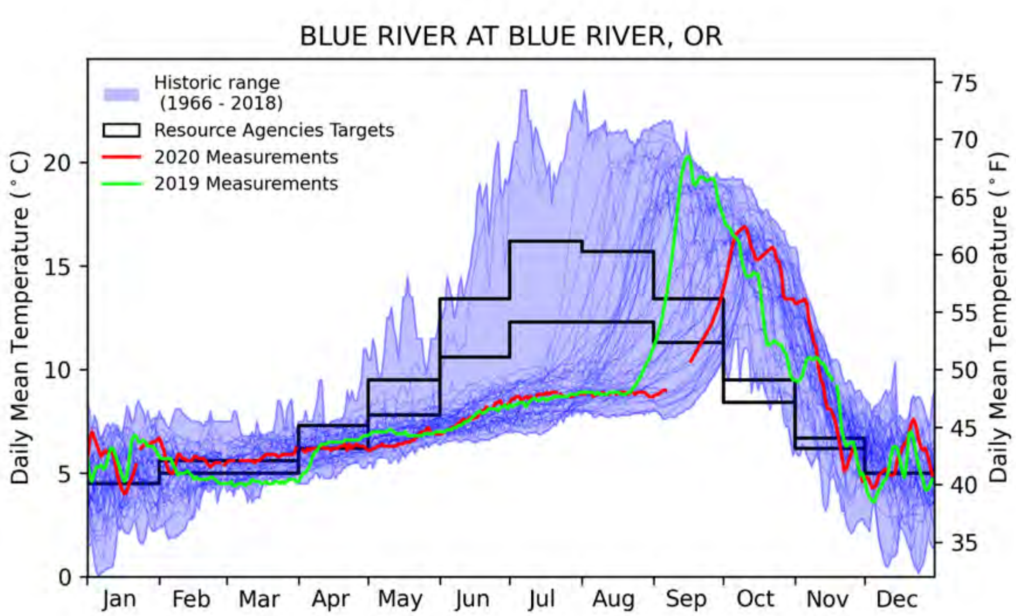



**Figure 3.5-20. Blue River at Blue River, OR. Blue River Reservoir Daily Mean 2019 and 2020 Outflow Temperatures compared to Cougar Dam's Resource Agencies Target Temperatures and Historical Temperature Range (1966 - 2018).** ***USACE 2020c, Draft*.**

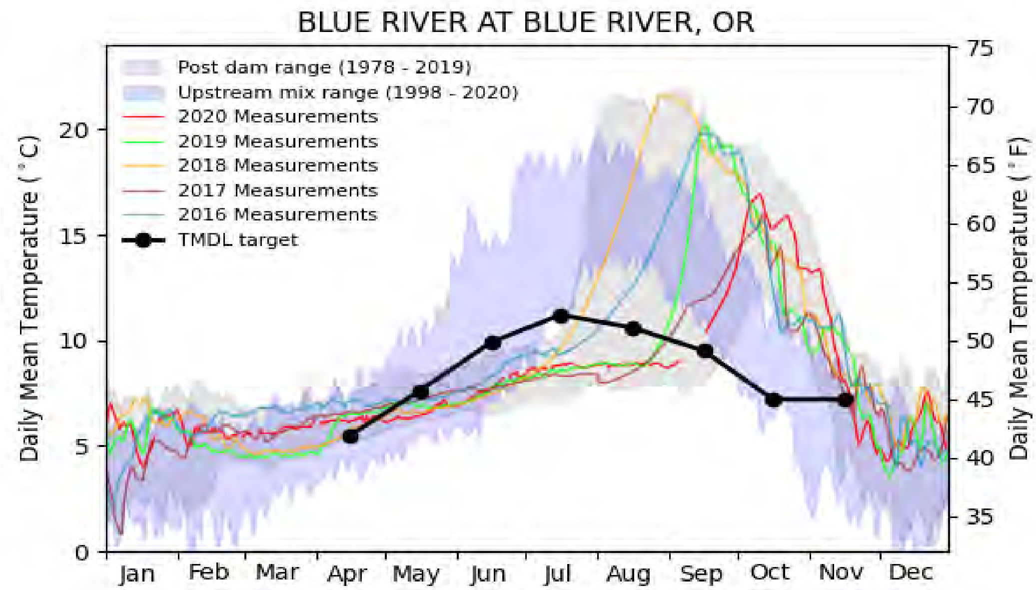



**Figure 3.5-21. Blue River at Blue River, OR. Blue River Reservoir Daily Mean Outflow Temperatures (2016 - 2020) Measured in the Blue River compared to Upstream Mix Range (1998 - 2020), Post Dam Range (1978 - 2019), and Oregon Department of Environmental Quality (ODEQ)'s Total Maximum Daily Load (TMDL) Monthly Median Target Temperatures.**

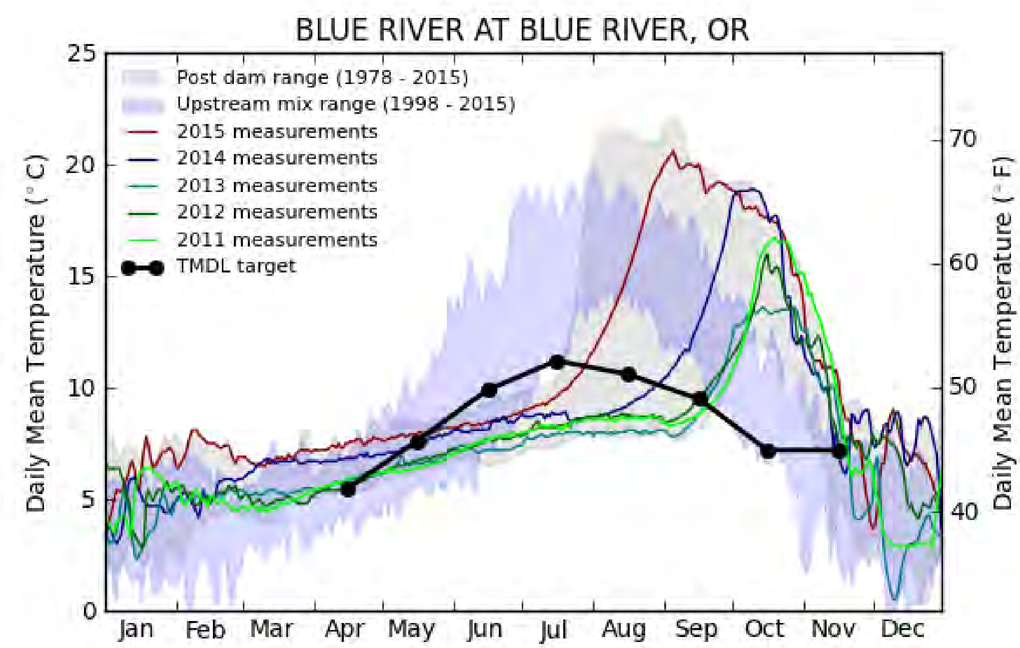



**Figure 3.5-22. Blue River at Blue River, OR. Blue River Reservoir Daily Mean Outflow Temperatures (2011 – 2015) Measured in the Blue River Compared to Upstream Mix Range (1998 – 2015), Post Dam Range (1978-2015), and ODEQ's TMDL Monthly Median Target Temperatures.**

#### *3.5.1.1.4 Middle Fork Willamette Sub-basin*

Currently, interim temperature management operations are not conducted at Hills Creek, Lookout Point or Dexter Reservoirs. However, informal temperature operations are implemented at Fall Creek from approximately March through October by utilizing the existing fish horns. Originally, the fish horns were constructed for fish to passage, however survivability was low. The nine fish horns are located at varying elevations (3-720 ft, 3-765 ft, 3-800 ft) and can provide water to the AFF. Although, with the fish horn elevations there is limited ability to affect the downstream temperatures. The primary use of the fish horns is to attract UWR spring Chinook salmon and UWR steelhead to the AFCF and secondarily for temperature. The Fall Creek spillway gates are not used for temperature management due to western pond turtle and Oregon chub habitat downstream.

Water temperature management operations were implemented at Lookout Point Dam from 2012 until 2014, by utilizing the spillway and powerhouse penstock to manage downstream water temperatures for UWR spring Chinook salmon. These operations and model simulations did not result in favorable downstream water temperatures. This is because inflow water temperatures are warmer, as compared to Detroit or Cougar Dams. Results from modeling analysis indicated only one day difference of egg emergence timing using the regulating outlet because it is 56 ft deeper than the powerhouse outlet (USACE 2015c). The Hills Creek spillway is used for emergency operations only, as its use would cause water to inundate the powerhouse below the dam. Therefore, no temperature management operations are currently conducted using the spillway.

In-reservoir thermistor temperature strings are deployed in Hills Creek, Lookout Point, Dexter, and Fall Creek Reservoirs. Hills Creek and Lookout Point temperature strings were deployed in 2010 and Dexter and Fall Creek Reservoirs were deployed in 2014 (USACE 2022). The thermistor string data measures the reservoir's thermal stratification throughout the year and helps to inform temperature management operations. USACE-funded USGS gages measure water temperature upstream and downstream of these reservoirs (Figure 3.5-23). RA temperature targets were developed for Hills Creek, Lookout Point, Dexter and Fall Creek Reservoirs (Table 3.5-6). The RA's consider estimated Middle Fork Willamette River fish emergence times which are generated yearly based on spawning time variability are also considered.

Historical temperature ranges at Hills Creek Reservoir have not exceeded 65°F in the summer, which is the optimal temperature for fish migration and holding (Figure 3.5-25). Figure 3.5-25 demonstrates the overlapping fish life cycle timeframe and temperature thresholds for holding, spawning, incubation, and migration. Temperatures at Hills Creek met most of the temperature targets from 2016 to 2020 but were lower than the TMDLs from 2011 to 2015 (Figure 3.5-25; Figure 3.5-26).

Outflow temperatures at Lookout Point/Dexter Dams can reach close to 70° F in the summer, optimal temperatures for fish migration and holding is approximately 50° F to 60 ° F (Figure 3.5-27). The outflow temperatures are generally close to the temperature TMDL targets for Lookout Point/Dexter, except from October through November when temperatures are higher

(Figure 3.5-28; Figure 3.5-29). At Fall Creek Reservoir the outflow temperatures are generally closest to the RA Targets and Temperature TMDLs from February through May (Figures 3.5-30; 3.5-31; 3.5-32).

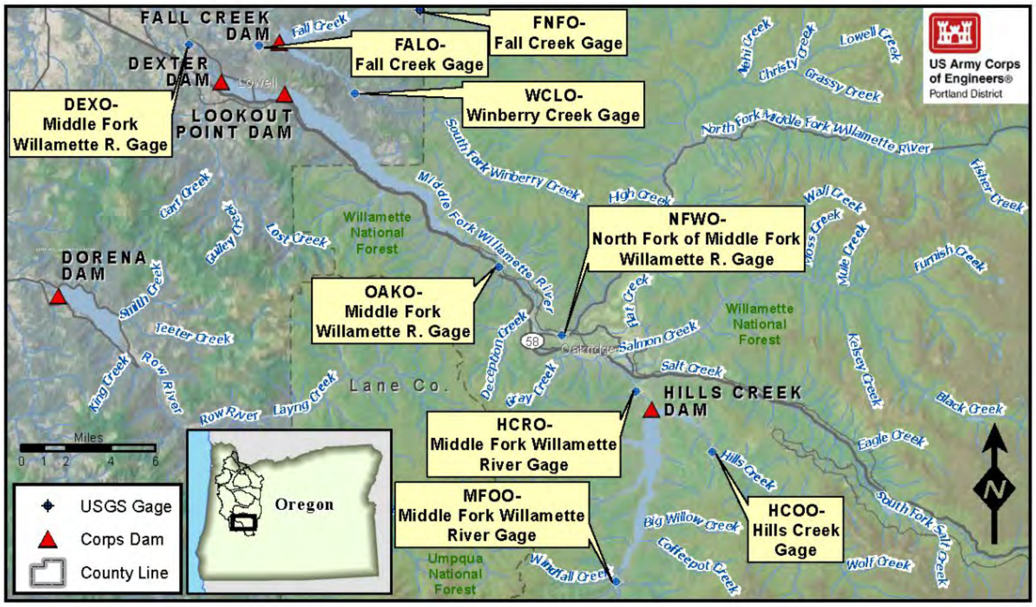



**Figure 3.5-23. Water Temperature USGS Gage Locations : Upstream and Downstream of Hills Creek, Lookout Point / Dexter, and Fall Creek Dams. USGS Data: http://or.water.usgs.gov/cgi-bin/grapher/table_setup.pl**

**Figure 3.5-24. Fall Creek Dam Surrogate Downstream Water Temperature Targets from Resource Agencies (Daily Average)* and Hills Creek, Lookout Point / Dexter, and Fall Creek ODEQ's 2006 TMDL Targets (Seven-Day Average).**

*Daily average target temperatures originally developed by the resource agencies (NMFS, USFWS, ODFW) for the McKenzie River below Cougar Dam (October and November slightly modified for the North Santiam River).

| Month | RA Target Temperature Range Maximum/Minimum* | | ODEQ 2006 TMDL Target Temperatures | | |
|---|---|---|---|---|---|
| | | | Hills Creek | Lookout Point/Dexter | Fall Creek |
| | °F | °F | °F | °F | °F |
| January | 40.1 | 40.1 | No Allocation Needed | | |
| February | 42.1 | 41.0 | | | |
| March | 42.1 | 41.0 | | | |
| April | 45.1 | 43.2 | 42.4 | 43.7 | 43.7 |
| May | 49.1 | 46.0 | 46.0 | 47.5 | 47.5 |
| June | 56.1 | 51.1 | 51.8 | 55.8 | 54.0 |
| July | 61.2 | 54.1 | 57.6 | 63.3 | 60.6 |
| August | 60.3 | 54.1 | 56.5 | 61.7 | 60.4 |
| September | 56.1 | 52.3 | 54.5 | 57.0 | 56.3 |
| October | <50.0 | <50.0 | 49.3 | 50.4 | 51.1 |
| November | <50.0 | <50.0 | 49.3 | 50.4 | 51.1 |
| December | 41.0 | 41.0 | No Allocation Needed | | |

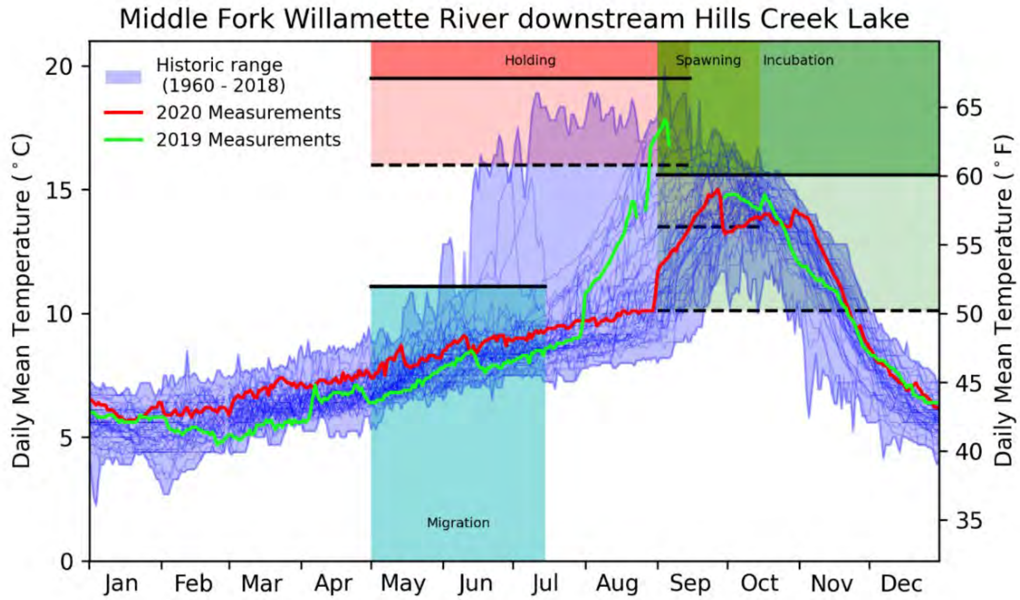



**Figure 3.5-25. Middle Fork Willamette River downstream of Hills Creek Lake. Hills Creek Reservoir Daily Mean 2019 and 2020 Outflow Temperatures compared to Water Quality Evaluation Criteria and Historical Temperature Range (1960 - 2018). USACE 2020c, *Draft*. Dashed line represents Chronic Temperatures. Solid line represents Acute Temperatures.**

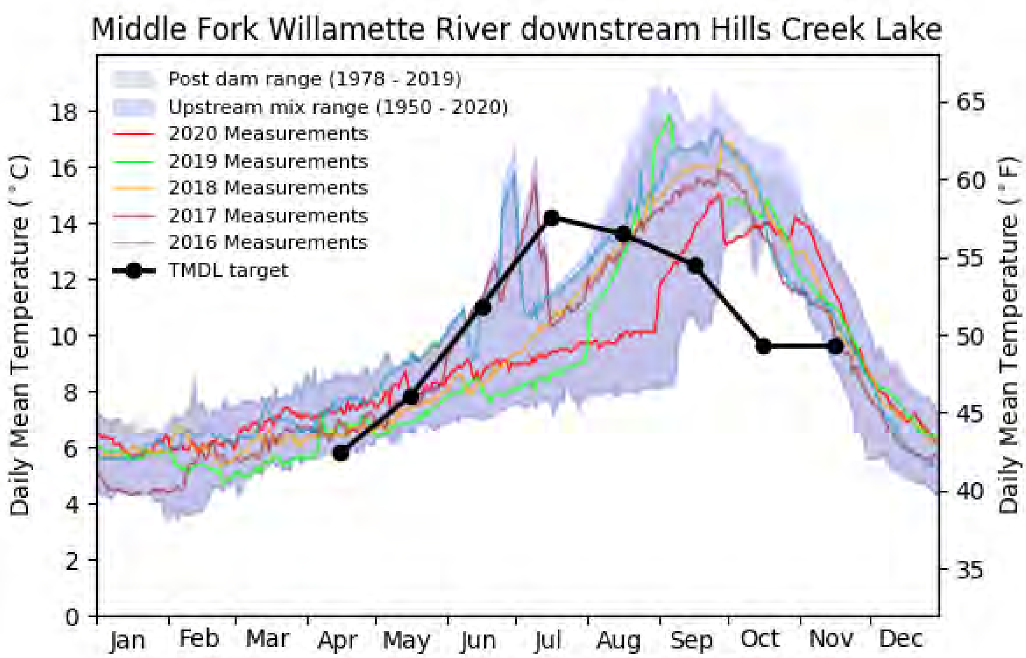



**Figure 3.5-26. Middle Fork Willamette River downstream of Hills Creek Lake. Hills Creek Reservoir Daily Mean Outflow Temperatures (2016 - 2020) Measured in the Middle Fork Willamette River compared to Upstream Mix Range (1916 - 2020), Post Dam Range (1978 - 2019), and Oregon Department of Environmental Quality (ODEQ)'s Total Maximum Daily Load (TMDL) Monthly Median Target Temperatures.**

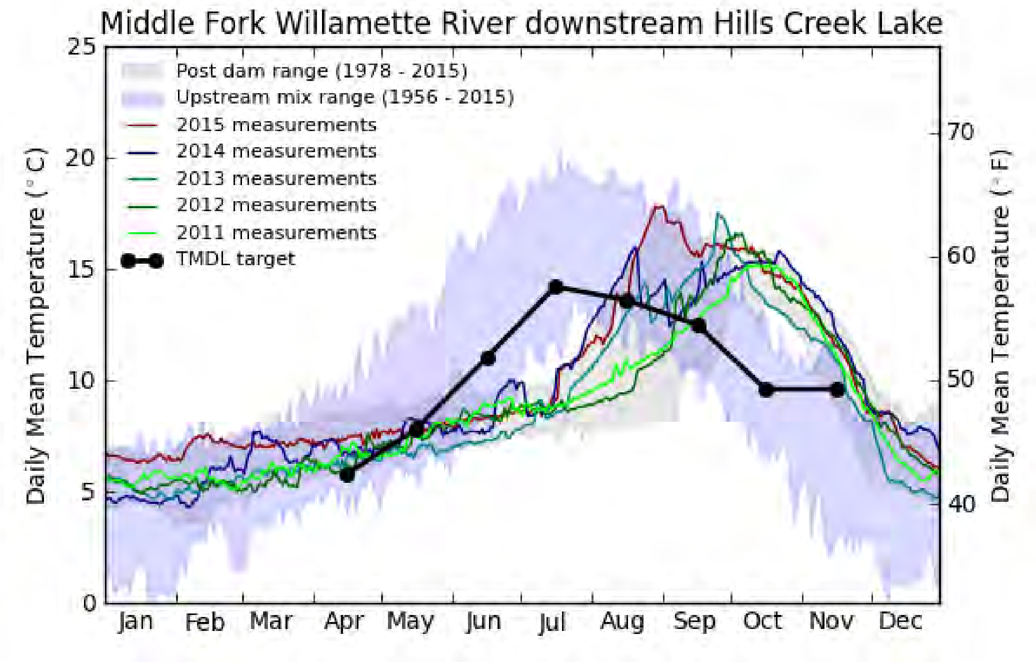



**Figure 3.5-27. Middle Fork Willamette River downstream of Hills Creek Lake. Hills Creek Reservoir Daily Mean Outflow Temperatures (2011 – 2015) Measured in the Middle Fork Willamette River Compared to Upstream Mix Range (1956 – 2015), Post Dam Range (1978-2015), and ODEQ's TMDL Monthly Median Target Temperatures.**

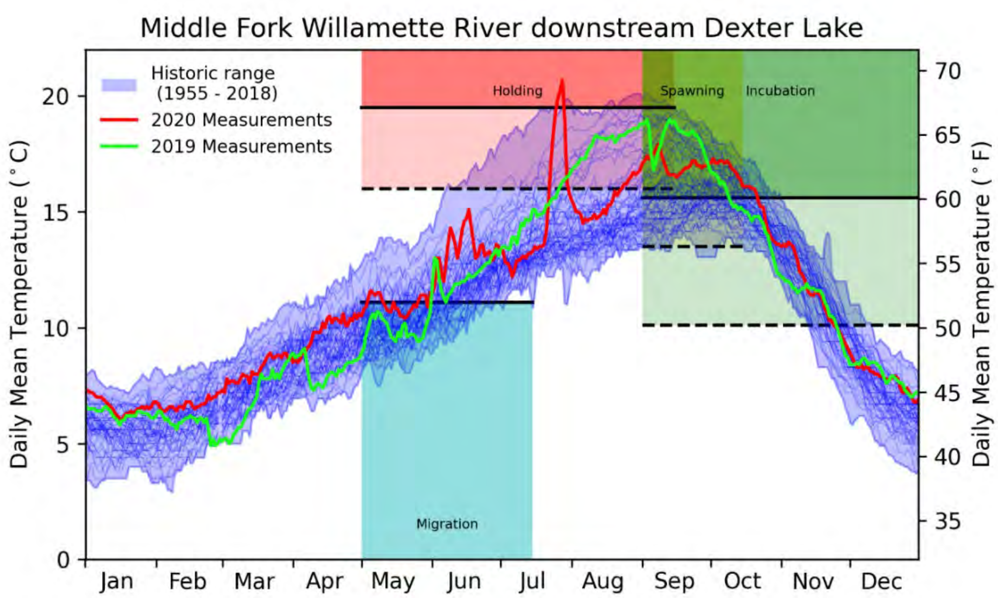



**Figure 3.5-28. Middle Fork Willamette River downstream of Dexter Lake. Lookout Point / Dexter Reservoirs Daily Mean 2019 and 2020 Outflow Temperatures compared to Water Quality Evaluation Criteria and Historical Temperature Range (1955 - 2018). USACE 2020c, *Draft*. Dashed line represents Chronic Temperatures. Solid line represents Acute Temperatures.**

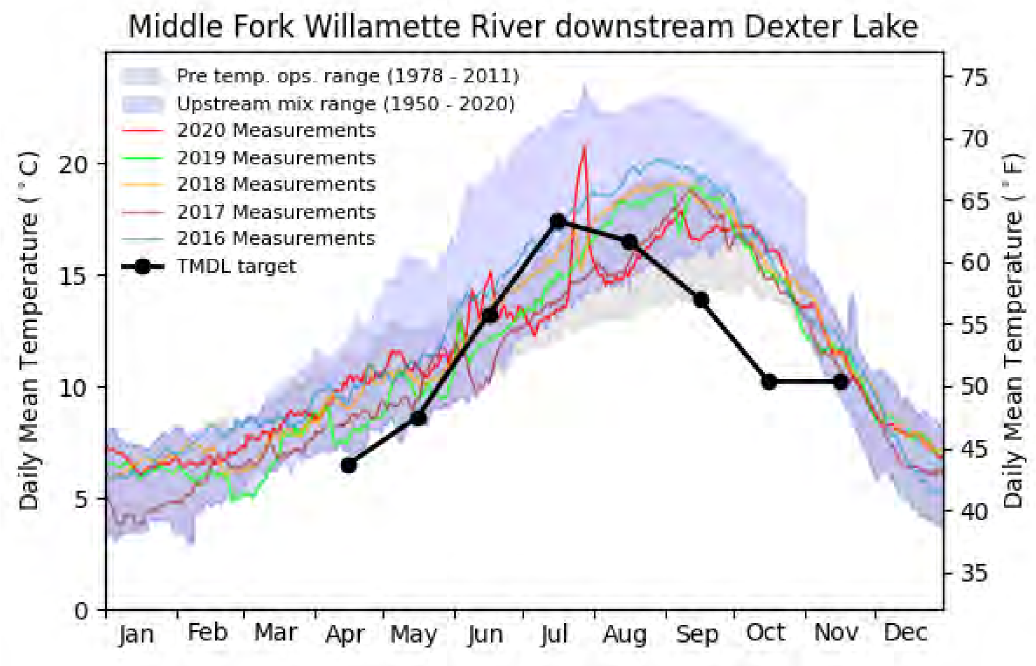



**Figure 3.5-29. Middle Fork Willamette River downstream of Dexter Lake. Lookout Point / Dexter Reservoirs Daily Mean Outflow Temperatures (2016 - 2020) Measured in the Middle Fork Willamette River compared to Upstream Mix Range (1950 - 2020), Pre-Temperature Operations Range (1978 - 2011), and Oregon Department of Environmental Quality (ODEQ)'s Total Maximum Daily Load (TMDL) Monthly Median Target Temperatures.**

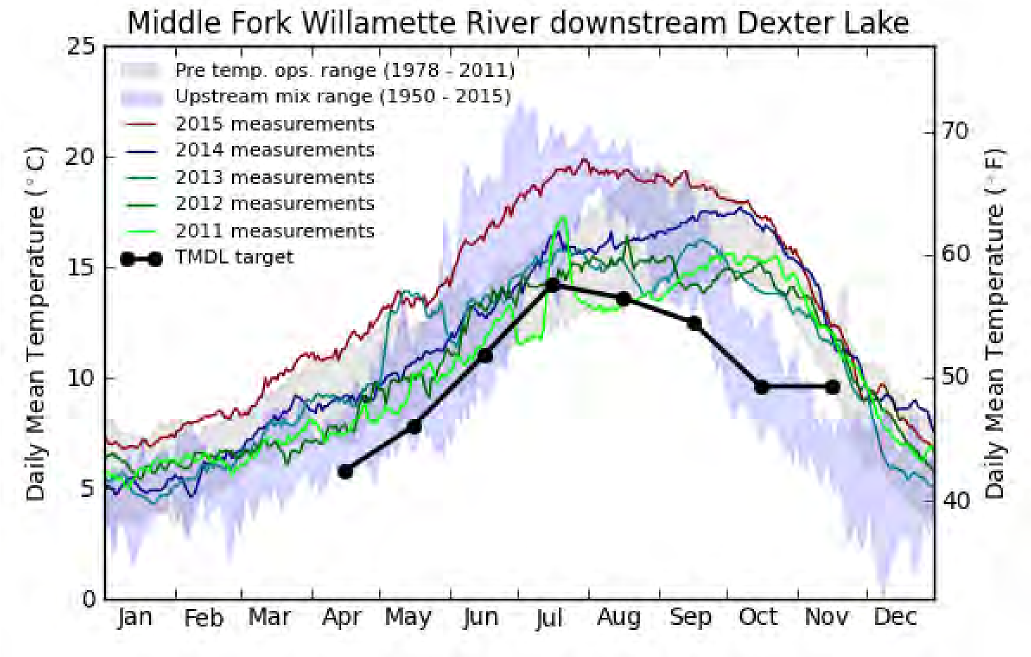



**Figure 3.5-30. Middle Fork Willamette River downstream of Dexter Lake. Lookout Point / Dexter Reservoirs Daily Mean Outflow Temperatures (2011– 2015) Measured in the Middle Fork Willamette River Compared to Upstream Mix Range (1950 – 2015), Pre-Temperature Operations Range (1978-2011), and ODEQ's TMDL Monthly Median Target Temperatures.**

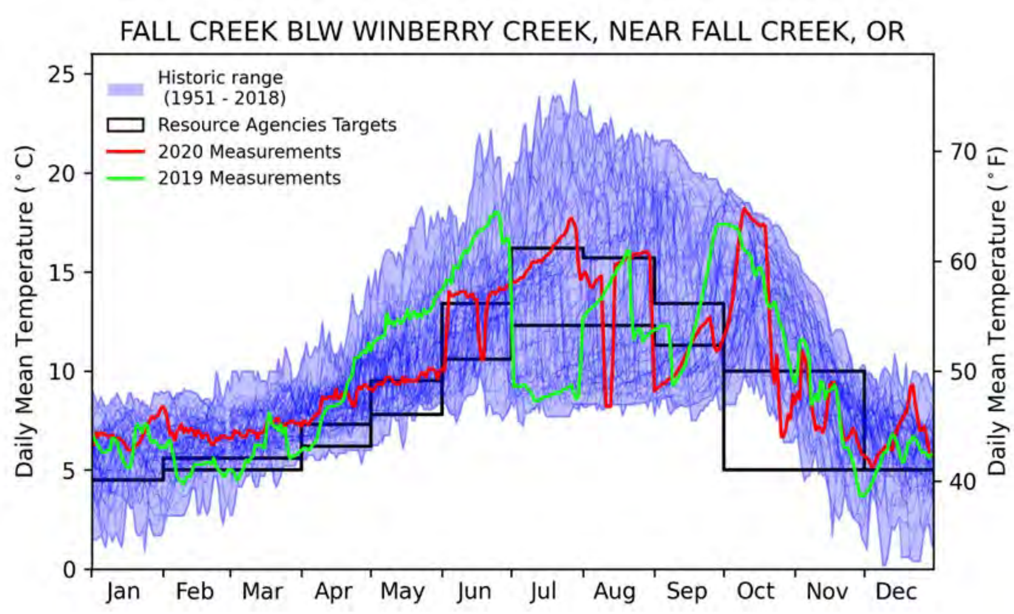



**Figure 3.5-31. Fall Creek below Winberry Creek, near Fall Creek, OR. Fall Creek Reservoir Daily Mean 2019 and 2020 Outflow Temperatures compared to Resource Agencies Target Temperatures and Historical Temperature Range (1951 - 2018). USACE 2020c, *Draft*.**

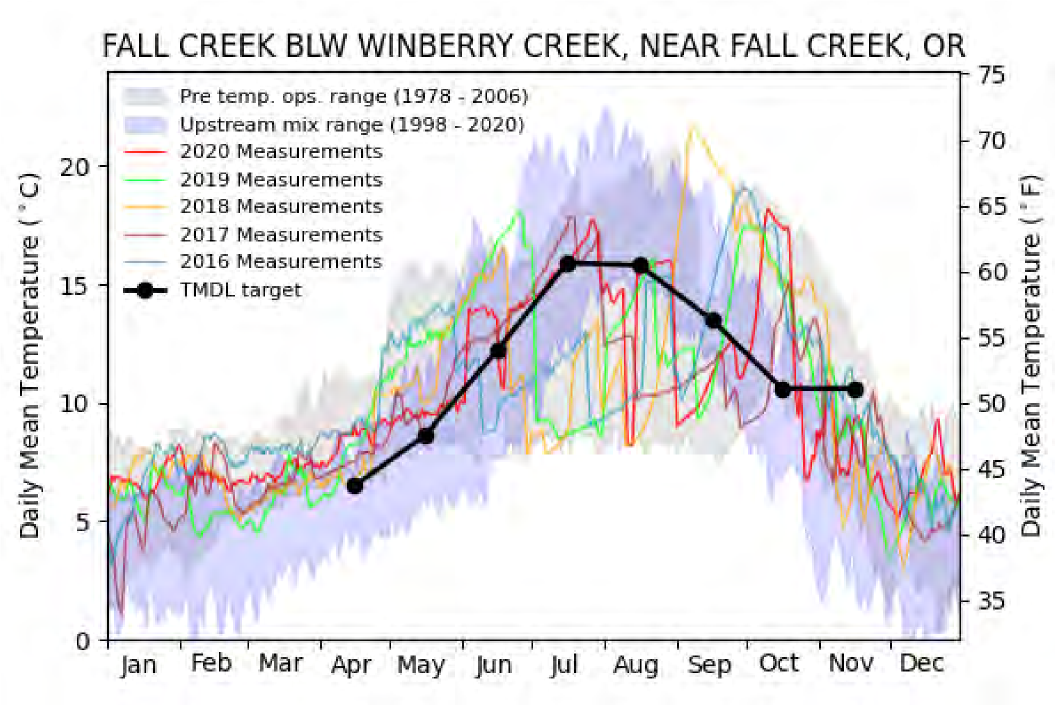



**Figure 3.5-32. Fall Creek below Winberry Creek, near Fall Creek, OR. Fall Creek Reservoir Daily Mean Outflow Temperatures (2016 - 2020) Measured in Fall Creek compared to Upstream Mix Range (1998 - 2020), Pre-Temperature Control Operations (informal) Range (1978 - 2006), and Oregon Department of Environmental Quality (ODEQ)'s Total Maximum Daily Load (TMDL) Monthly Median Target Temperatures.**

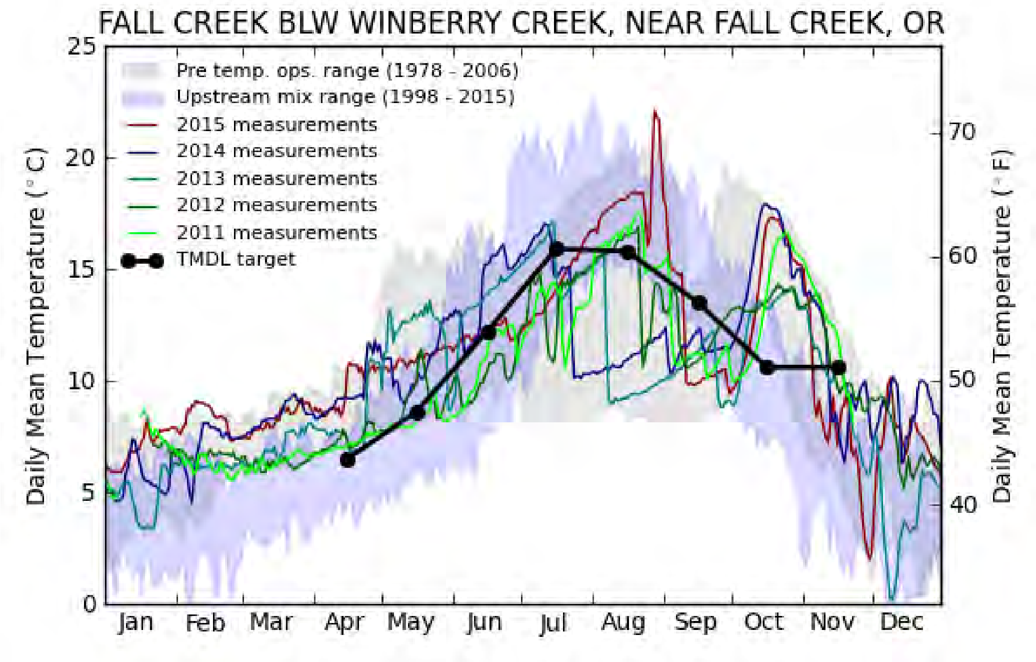



**Figure 3.5-33. Fall Creek below Winberry Creek, near Fall Creek, OR. Fall Creek Reservoir Daily Mean Outflow Temperatures (2011 – 2015) Measured in Fall Creek Compared to Upstream Mix Range (1998 – 2015), Pre-Temperature Control Operations (informal) Range (1978 – 2006), and ODEQ's TMDL Monthly Median Target Temperatures.**

*3.5.1.1.5 Coast Fork and Long Tom Sub-basins*

Temperature control operations are not conducted at Cottage Grove, Dorena and Fern Ridge Reservoirs. USACE-funded USGS gages monitor temperature at inflow points and outflow points of Cottage Grove, Dorena, and Fern Ridge Reservoirs (Figure 3.5-33). There are no RA temperature targets implemented at these reservoirs, although there are Temperature TMDLs (Table 3.5-7). There are no temperature strings deployed at these reservoirs that provide thermal stratification data.

Historically, Cottage Grove outflow temperatures are warmest in August and begin to cool in late-September (Figure 3.5-34). Outflow temperatures at Cottage Grove have been closest to the TMDL targets from April through May and October through November. However, summer temperatures are generally cooler than the TMDL except in 2015 when the target was briefly met (Figure 3.5-35; Figure 3.5-36). Dorena Reservoir outflow temperatures are historically warmest in late-August and begin to cool by early October (Figure 3.5-37). Summer outflow temperatures at Dorena are cooler than the TMDL targets, as observed from 2011 – 2020 (Figure 3.5-38; Figure 3.5-39). Fern Ridge outflow temperatures are typically warmest in August and begin to cool in September (Figure 3.5-40). Outflow temperatures are warmer than the TMDL targets, as observed from 2011 – 2020 (Figure 3.5-41; Figure 3.5-42).

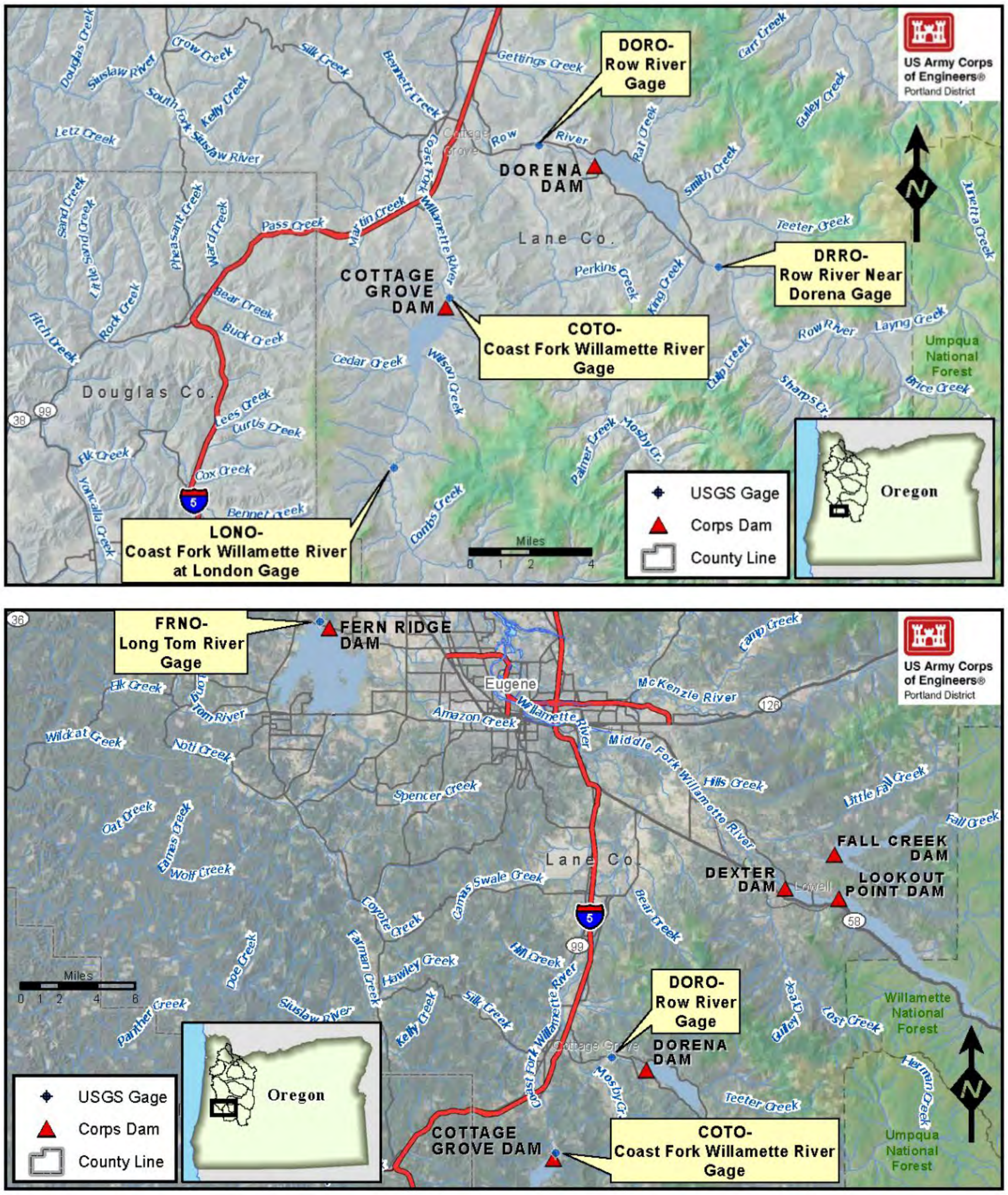



**Figure 3.5-34. Water Temperature USGS Gage Locations: Downstream of Cottage Grove and Dorena Dams (top) and Fern Ridge Dam (bottom).**

USGS Data: http://or.water.usgs.gov/cgi-bin/grapher/table_setup.pl

**Table 3.5-5. Cottage Grove, Dorena, and Fern Ridge Dams Downstream Water Temperature Targets from ODEQ's 2006 TMDL Targets (Seven-Day Average).**

| Month | ODEQ 2006 TMDL Target Temperatures | | |
|---|---|---|---|
| | Cottage Grove °F | Dorena °F | Fern Ridge °F |
| January | No Allocation Needed | | |
| February | | | |
| March | | | |
| April | 48.9 | 47.8 | 48.2 |
| May | 52.5 | 51.4 | 51.4 |
| June | 59.9 | 61.7 | 58.3 |
| July | 67.8 | 72.1 | 62.1 |
| August | 64.9 | 68.7 | 60.8 |
| September | 61.5 | 64.8 | 57.2 |
| October | 56.3 | 59.5 | 46.4 |
| November | No Allocation Needed | | |
| December | | | |

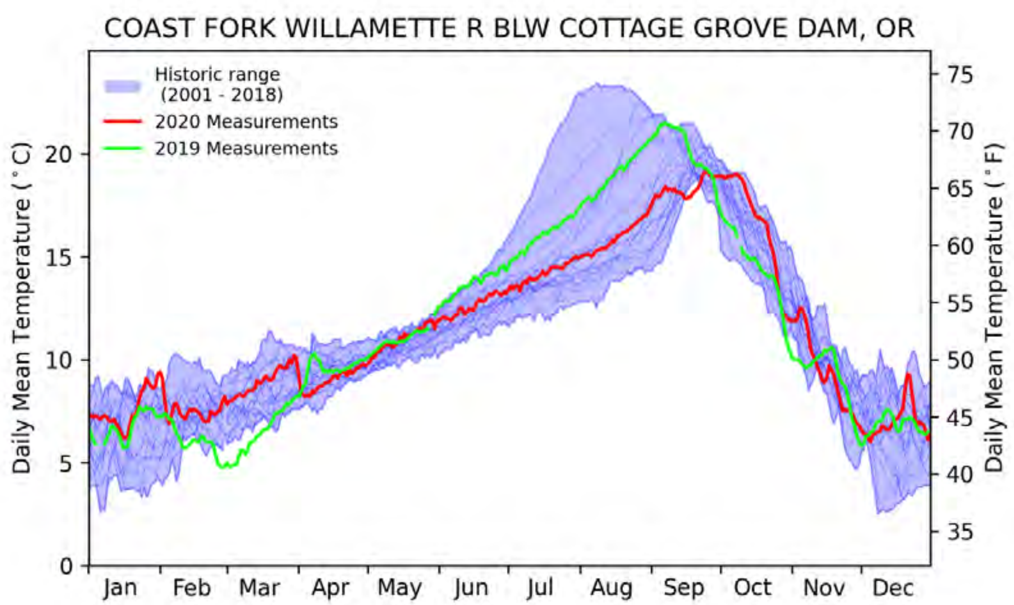



**Figure 3.5-35. Coast Fork Willamette River below Cottage Grove Dam, OR. Cottage Grove Reservoir Daily Mean Outflow Temperatures Measured in the Coast Fork Willamette River for 2020, compared to Oregon Department of Environmental Quality (ODEQ)'s Total Maximum Daily Load (TMDL) Monthly Median Target Temperatures (top); Daily Mean 2019 and 2020 Outflow Temperatures compared to Historical Temperature Range (2001 - 2018) (bottom).**

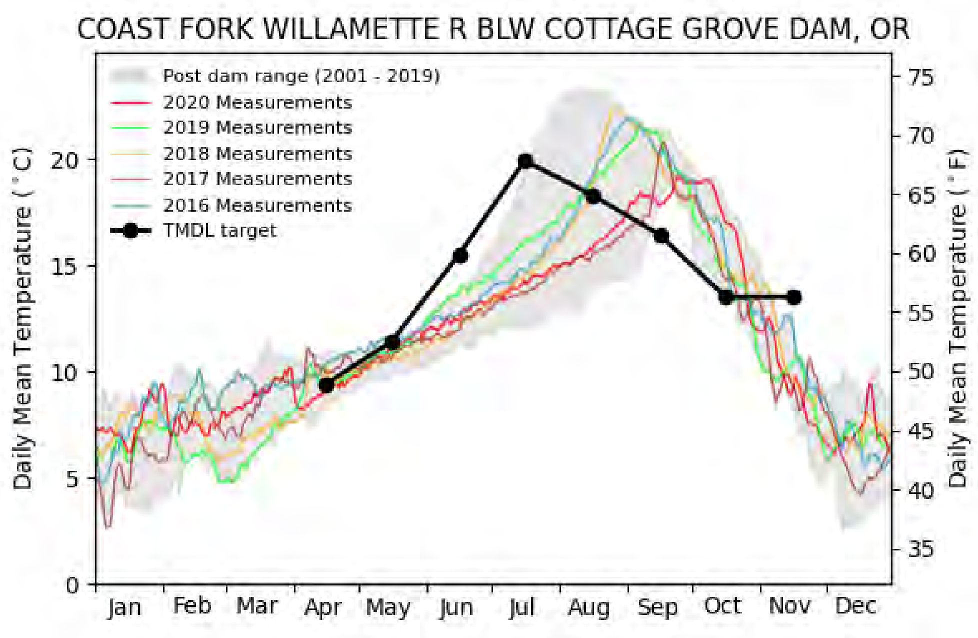



**Figure 3.5-36. Coast Fork Willamette River below Cottage Grove Dam, OR. Cottage Grove Reservoir Daily Mean Outflow Temperatures (2016 - 2020) Measured in Coast Fork Willamette River compared to Post Dam Range (2001 - 2019) and Oregon Department of Environmental Quality (ODEQ)'s Total Maximum Daily Load (TMDL) Monthly Median Target Temperatures.**

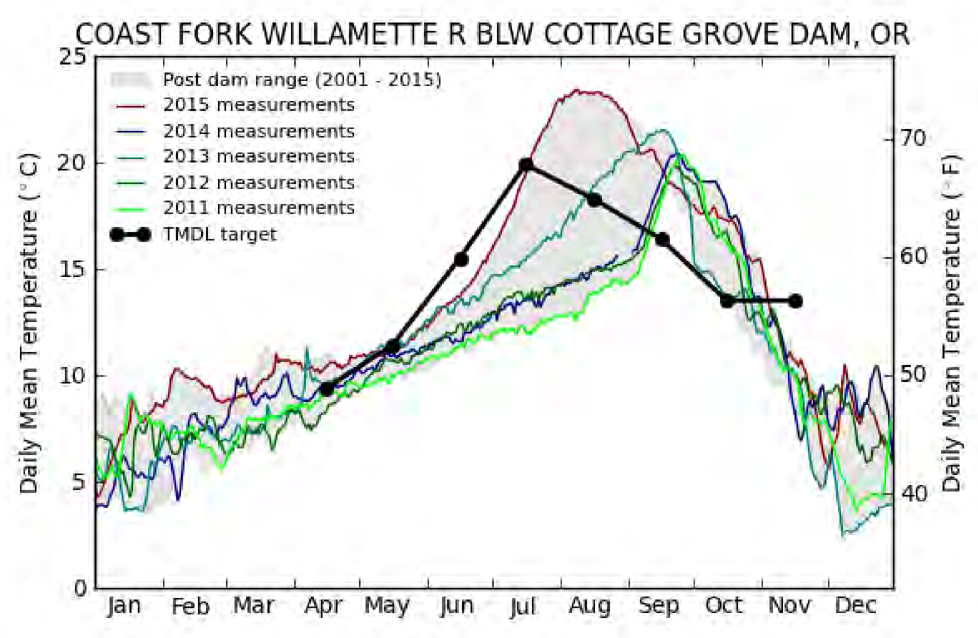



**Figure 3.5-37. Coast Fork Willamette River below Cottage Grove Dam, OR. Cottage Grove Reservoir Daily Mean Outflow Temperatures (2011 – 2015) Measured in Coast Fork Willamette River Compared to Post Dam Range (2001-2015) and ODEQ's TMDL Monthly Median Target Temperatures.**

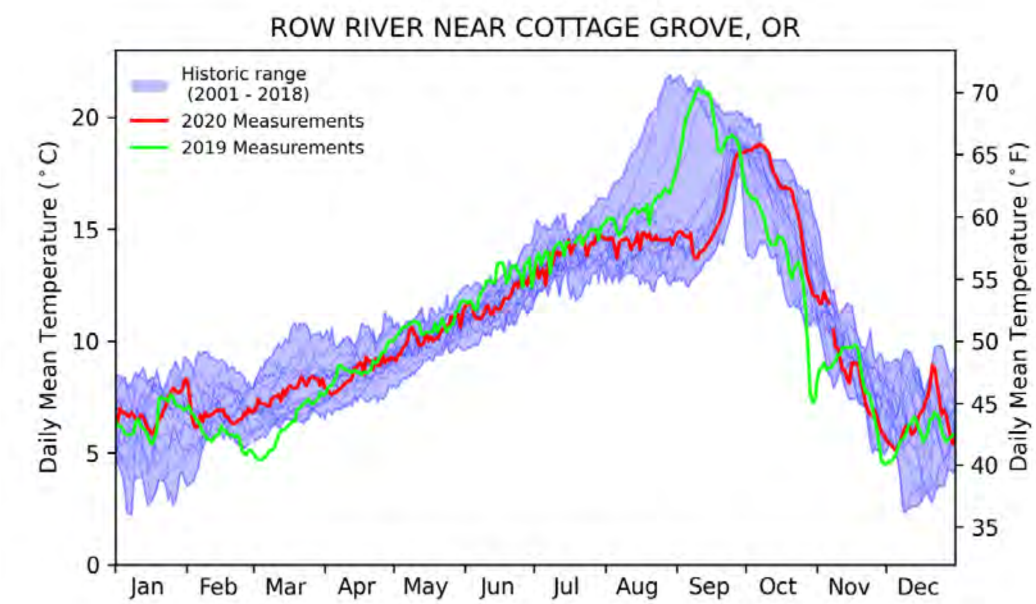



**Figure 3.5-38. Row River near Cottage Grove, OR. Dorena Reservoir Daily Mean Outflow Temperatures Measured in the Row River for 2020, compared to Oregon Department of Environmental Quality (ODEQ)'s Total Maximum Daily Load (TMDL) Monthly Median Target Temperatures (top); Daily Mean 2019 and 2020 Outflow Temperatures compared to Historical Temperature Range (2001 - 2018) (bottom).**

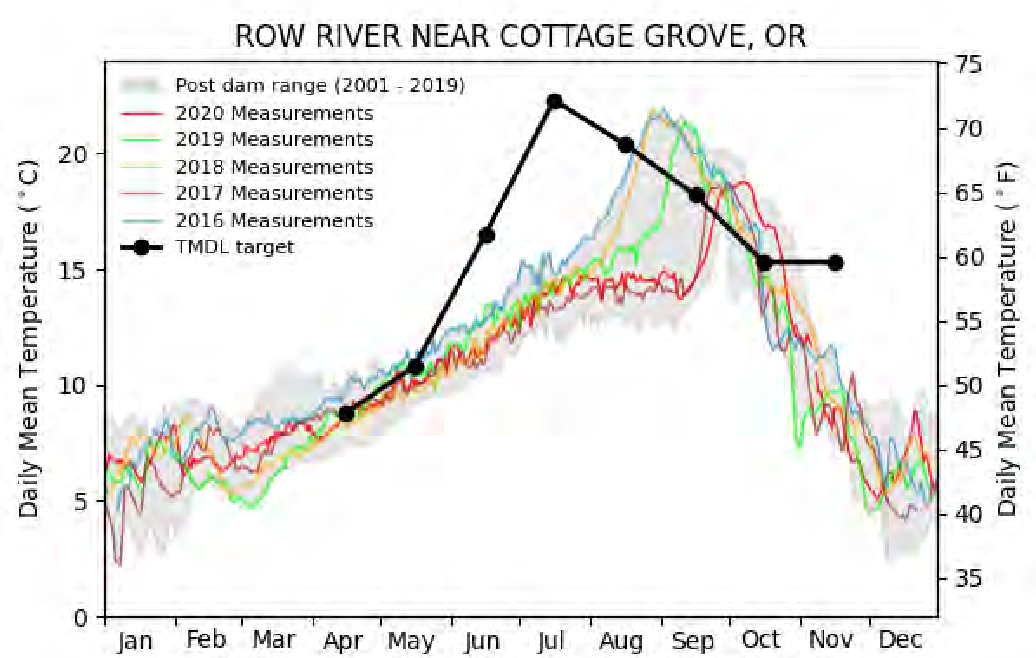



**Figure 3.5-39. Row River near Cottage Grove, OR. Dorena Reservoir Daily Mean Outflow Temperatures (2016 - 2020) Measured in Row River compared to Post Dam Range (2001 - 2019) and Oregon Department of Environmental Quality (ODEQ)'s Total Maximum Daily Load (TMDL) Monthly Median Target Temperatures.**

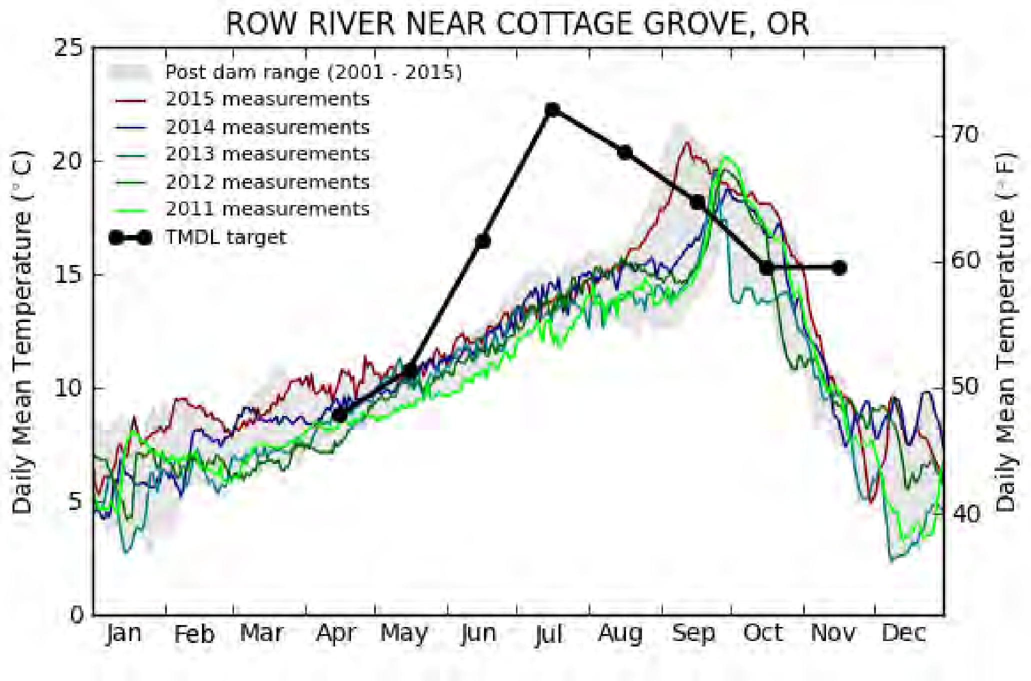



**Figure 3.5-40. Row River near Cottage Grove, OR. Dorena Reservoir Daily Mean Outflow Temperatures (2011 – 2015) Measured in Row River Compared to Post Dam Range (2001 – 2015) and ODEQ's TMDL Monthly Median Target Temperatures.**

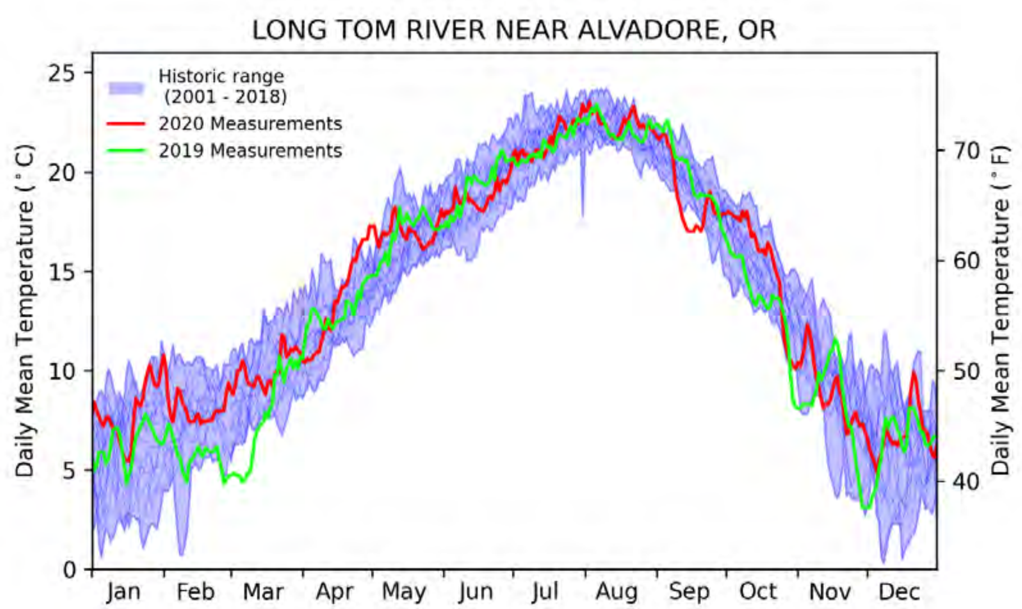



**Figure 3.5-41. Long Tom River near Alvadore, OR. Fern Ridge Reservoir Daily Mean Outflow Temperatures Measured in the Long Tom River for 2020, compared to Oregon Department of Environmental Quality (ODEQ)'s Total Maximum Daily Load (TMDL) Monthly Median Target Temperatures (top); Daily Mean 2019 and 2020 Outflow Temperatures compared to Historical Temperature Range (2001 - 2018) (bottom).**

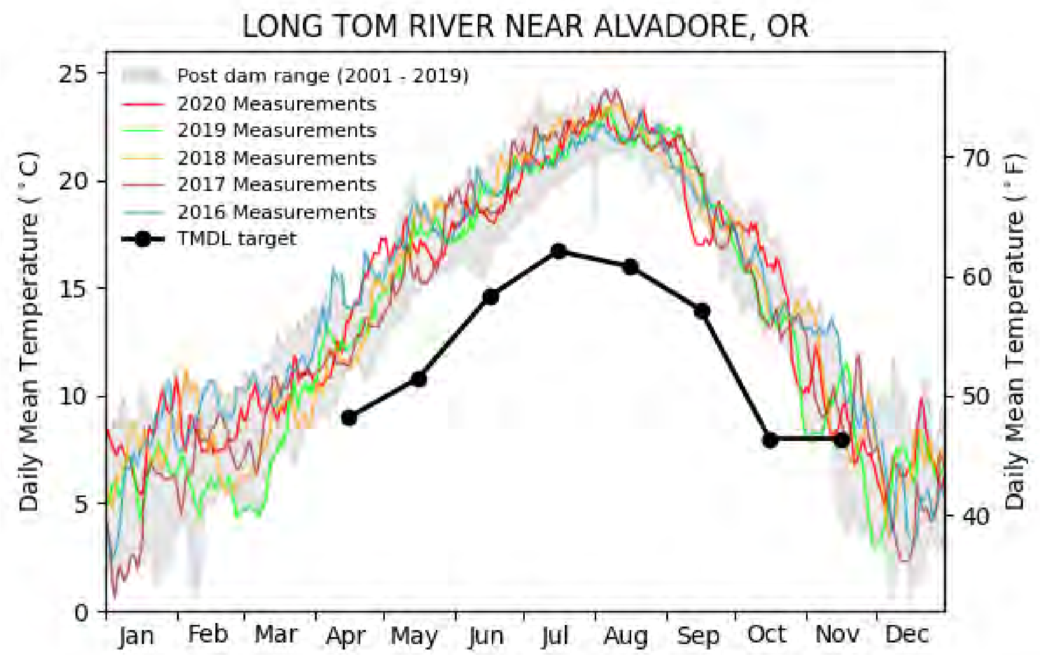



**Figure 3.5-42. Long Tom River near Alvadore, OR. Fern Ridge Reservoir Daily Mean Outflow Temperatures (2016 - 2020) Measured in Long Tom River compared to Post Dam Range (2001-2019) and Oregon Department of Environmental Quality (ODEQ's) TMDL Monthly Median Target Temperatures.**

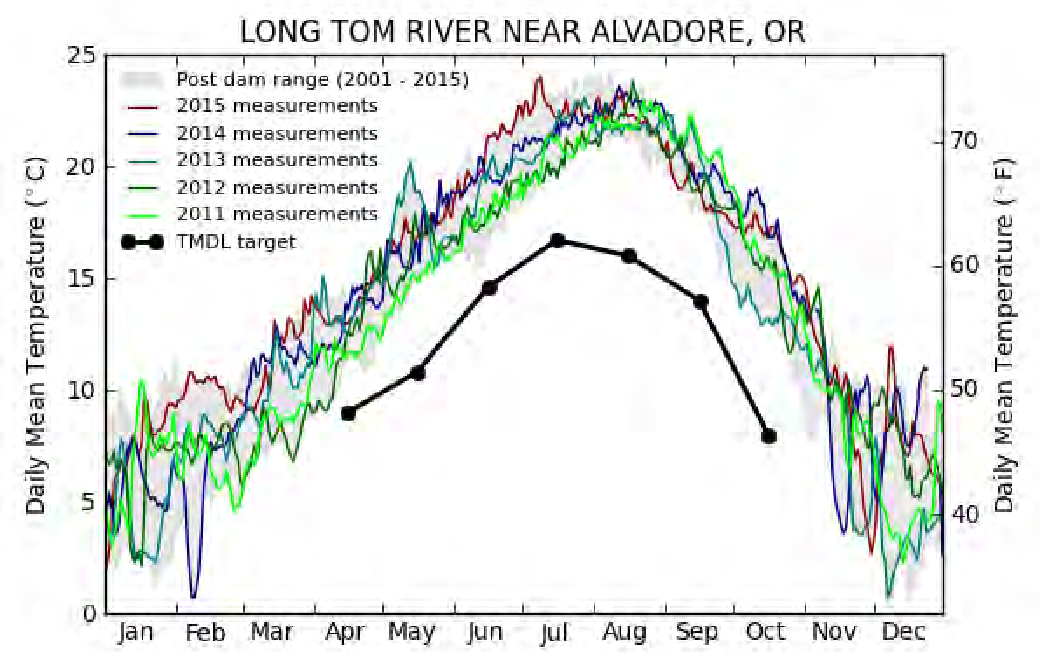



**Figure 3.5-43. Long Tom River near Alvadore, OR. Fern Ridge Reservoir Daily Mean Outflow Temperatures (2011 – 2015) Measured in Long Tom River Compared to Post Dam Range (2001 – 2015) and ODEQ's TMDL Monthly Median Target Temperatures.**

### *3.5.1.2 Total Dissolved Gas*

TDG is a measure of dissolved atmospheric gases in water. The primary gases that make up TDG are oxygen, nitrogen, and carbon dioxide. TDG levels are dependent on a variety of factors, including discharge rate (flow), pressure (depth) and water temperature. TDG is monitored by USACE-funded USGS gages. Elevated TDG can be created by the entrainment of air as the water is released through regulating outlets or spillway operations. Water released through dam outlets plunges into the tailrace, entraining and forcing air into solution, which can cause elevated TDG concentrations in the river below.

TDG levels above 110% saturation can adversely affect juvenile salmonids through gas bubble trauma (GBT), an effect similar to underwater diving decompression sickness or “the bends” in humans (Mesa et al, 2000). However there have been studies that indicate TDG levels up to 120% may not impact salmonids during less sensitive life stages, depending on depth compensation and other factors (McGrath et al. 2006). Fish residing in shallow or near-surface depths at certain stages of their life cycle are more at risk (Maynard 2008). As stated in the Oregon Administrative Rules (OAR) 340-041-0031:

> “Except when stream flow exceeds the ten-year, seven-day average flood, the concentration of total dissolved gas relative to atmospheric pressure at the point of sample collection may not exceed 110% of saturation. However, in hatchery-receiving waters and other waters of less than two feet in depth, the concentration of total dissolved gas relative to atmospheric pressure at the point of sample collection may not exceed 105% of saturation.”

#### *3.5.1.2.1 North Santiam Sub-basin*

TDG exceedances greater than Oregon standard of 110% can be observed downstream of Detroit and Big Cliff Dams when water is released through the non-turbine outlets of dams. TDG is monitored in real-time at the USGS gage (BCLO) located 0.75 miles below Big Cliff Reservoir near Niagara, Oregon (Figure 3.5-43).

A TDG study was conducted within the North Santiam River in 2010 (June - November) (USACE 2011). TDG saturation measurements were recorded at Detroit and Big Cliff Dam tailraces, Niagara, Minto Fish Facility and Mehama. This study determined that TDG produced by the USACE dams degasses as water moves downstream, typically returning to background levels by the time it reaches Mehama, Oregon, 20 miles downstream of the dams (Figure 3.5-43; USACE 2011).

Although TDG exceedances do occur on occasion from spill and maintenance operations at Detroit or Big Cliff Dams, elevated TDG is typically observed nearest the dams and is not found to persist downstream. Exceedances generally occur in the Fall and spring months when water is released for flood management due to precipitation events. For instance, in May 2013 TDG levels reached 120% TDG for 13 days due to high flows and spill at Detroit and Big Cliff dams for flood management. A compilation of TDG exceedances from 2012 to 2020 is provided with explanations (Figure 3.5-45).

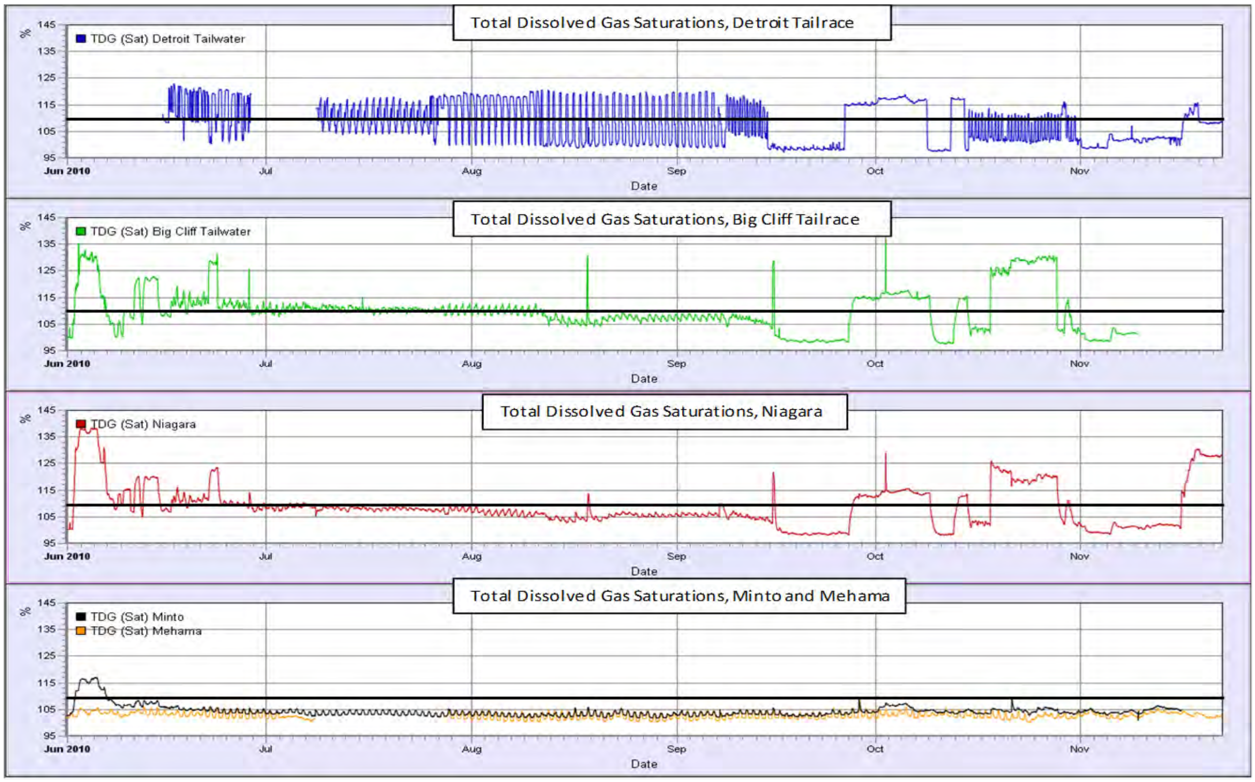



**Figure 3.5-44. Total Dissolved Gas Saturation Measured in the Detroit and Big Cliff Tailraces and Near Niagara, Minto and Mehama on the North Santiam River, June through November, 2010. Black line denotes Oregon criteria for TDG of 110% level. Excerpt from the *Willamette Basin Annual Water Quality Report for Water Year 2010, pg. 25***

| ` | 2020 | | | 2019 | | | 2018 | | |
|---|---|---|---|---|---|---|---|---|---|
| **MONTH** | **MAX % TDG** | **DAYS** | **REASON** | **MAX % TDG** | **DAYS** | **REASON** | **MAX % TDG** | **DAYS** | **REASON** |
| **Jan** | 135 | 7 | 3, 4, 7 | --- | --- | --- | 132 | 1 | 3 |
| **Feb** | 126 | 4 | 3, 4 | --- | --- | --- | --- | --- | --- |
| **Mar** | 118 | 3 | 7 | 118 | 28 | 1, 7 | 117 | 1 | 1 |
| **Apr** | 115 | 15 | 7 | 131 | 23 | 1, 3, 4 | --- | --- | --- |
| **May** | 120 | 1 | 1 | --- | --- | --- | 127 | 1 | 1, 3 |
| **Jun** | 118 | 9 | 6 | --- | --- | --- | 121 | 13 | 1, 6 |
| **Jul** | 119 | 14 | 1, 6 | --- | --- | --- | 120 | 3 | 1, 6 |
| **Aug** | 118 | 13 | 1, 6 | 118 | 2 | 1 | 118 | 2 | 1 |
| **Sep** | 118 | 23 | 1 | 121 | 1 | 1 | --- | --- | --- |
| **Oct** | 122 | 31 | 1 | 118 | 4 | 1 | 125 | 17 | 1, 6 |
| **Nov** | 128 | 30 | 1, 2, 3, 4 | 126 | 13 | 3, 6 | 120 | 2 | 1 |
| **Dec** | 119 | 21 | 2, 3, 4 | 116 | 3 | 7 | --- | --- | --- |
| **Total days** | | 171 | | | 74 | | | 40 | |
| | **2017** | | | **2016** | | | **2015** | | |
| **MONTH** | **MAX % TDG** | **DAYS** | **REASON** | **MAX % TDG** | **DAYS** | **REASON** | **MAX % TDG** | **DAYS** | **REASON** |
| **Jan** | 123 | 2 | 1 | 126 | 14 | 3, 4 | 125 | 5 | 3 |
| **Feb** | 132 | 15 | 1, 3 | --- | --- | --- | 112 | 5 | 3 |
| **Mar** | 138 | 31 | 1 | 115 | 6 | 1 | 121 | 18 | 1 |
| **Apr** | 129 | 14 | 1, 4 | 127 | 27 | 1 | --- | --- | --- |
| **May** | 130 | 30 | 3, 4 | 125 | 17 | 1 | 119 | 4 | 1 |
| **Jun** | 126 | 25 | 1, 6 | 122 | 7 | 1, 6 | --- | --- | --- |
| **Jul** | 117 | 8 | 1, 6 | 116 | 9 | 6 | --- | --- | --- |
| **Aug** | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sep** | 112 | 1 | 7 | 118 | 1 | 1, 7 | 112 | 2 | 6 |
| **Oct** | 129 | 15 | 3, 5 | 126 | 22 | 3, 6 | 120 | 23 | 6 |
| **Nov** | 120 | 19 | 3, 6 | 124 | 11 | 3, 6 | 114 | 4 | 6 |
| **Dec** | --- | --- | --- | 125 | 12 | 1, 3 | 136 | 20 | 3, 4 |
| **Total days** | | 160 | | | 126 | | | 81 | |
| | **2014** | | | **2013** | | | **2012** | | |
| **MONTH** | **MAX % TDG** | **DAYS** | **REASON** | **MAX % TDG** | **DAYS** | **REASON** | **MAX % TDG** | **DAYS** | **REASON** |
| **Jan** | --- | --- | --- | 127 | 4 | 1, 3, 4 | 132 | 31 | 1, 3, 7 |
| **Feb** | 131 | 11 | 3, 4 | 123 | 28 | 1, 7 | 132 | 15 | 1, 3 |
| **Mar** | 133 | 21 | 3, 4 | 123 | 24 | 1, 7 | 128 | 27 | 1 |
| **Apr** | 129 | 24 | 1 | 116 | 6 | 2 | 132 | 30 | 1, 7 |
| **May** | 133 | 31 | 1 | 120 | 13 | 3, 4 | 131 | 29 | 1, 7 |
| **Jun** | 122 | 24 | 1, 6 | 112 | 16 | 6 | 129 | 29 | 1, 7 |
| **Jul** | 112 | 16 | 6 | 125 | 16 | 6 | 117 | 19 | 7 |
| **Aug** | 111 | 6 | 6 | 119 | 1 | 6 | --- | --- | --- |
| **Sep** | 122 | 1 | 1 | 124 | 4 | 1, 7 | 124 | 5 | 1, 7 |
| **Oct** | 130 | 5 | 1, 7 | 129 | 2 | 3 | 127 | 8 | 1, 7 |
| **Nov** | 122 | 4 | 1, 7 | 130 | 20 | 3 | 130 | 28 | 1, 7 |
| **Dec** | 136 | 19 | 3, 4 | 128 | 10 | 3 | 129 | 31 | 1, 7 |
| **Total days** | | 162 | | | 144 | | | 252 | |
| **Notes:** | An exceedance is considered any percent of Total Dissolved Gas greater than Oregon Standard of 110%. TDG data measurements began in June 2011 downstream of Detroit Dam. | | | | | | | | |
| **[ 1 ]** | Spill @ Big Cliff with Unit Out of Service (OOS) (i.e., due to wild fires in 2020) | | | | | | | | |
| **[ 2 ]** | Spill @ Detroit for Downstream Fish Passage Testing | | | | | | | | |
| **[ 3 ]** | High flows and Spill @ Big Cliff for Flood Management | | | | | | | | |
| **[ 4 ]** | High flows and Spill @ Detroit for Flood Management | | | | | | | | |
| **[ 5 ]** | Spill @ Big Cliff with Unit OOS for Environmental Study SOR | | | | | | | | |
| **[ 6 ]** | Spill @ Detroit for Temperature Control Operations | | | | | | | | |
| **[ 7 ]** | Spill @ Detroit with Unit OOS (i.e., spillway repairs in Dec. 2019) | | | | | | | | |

**Figure 3.5-45. Big Cliff Dam Total Dissolved Gas Exceedances greater than the Oregon State Standard of 110% Saturation (hourly), Measured near Niagara, 2012 – 2020, and Including the Maximum Exceedance Value, Number of Days with Hourly Exceedances, and the Reason for Exceeding the State Standard.**

#### *3.5.1.2.2 South Santiam Sub-basin*

TDG is not monitored downstream of Green Peter Dam, but Foster Dam instead. This sensor was installed in May 2015. Elevated TDG levels can occur when the outflow of water exceeds the powerhouse capacity and spillway discharge. A compilation of TDG exceedances from 2015 to 2020 is provided with explanations (Figure 3.5-46). For instance, in April 2019 TDG levels reached 121% for 10 days due to spill operations for flood management from a precipitation event. The USACE has updated TDG regression equations for tailwaters below Big Cliff Dam (and Cougar, Foster, and Dexter dams) using data from 2011 to 2020. These equations are based on System Total Dissolved Gas (SYSTDG) formulas used in the Columbia River system. The equations will assist in real-time Willamette Project operations and allow a quantified comparison of TDG resulting from operations in the Willamette Valley PEIS (refer to Technical Report for equation formula).

| | 2020 | | | 2019 | | | 2018 | | |
|---|---|---|---|---|---|---|---|---|---|
| MONTH | MAX % TDG | DAYS | REASON | MAX % TDG | DAYS | REASON | MAX % TDG | DAYS | REASON |
| Jan | 117 | 2 | 1 | 115 | 1 | 1 | --- | --- | |
| Feb | --- | --- | | --- | --- | | --- | --- | |
| Mar | --- | --- | | --- | --- | | 112 | 1 | 1,2 |
| Apr | --- | --- | | 121 | 10 | 1 | 114 | 5 | 1 |
| May | 116 | 14 | 1 | --- | --- | | 113 | 4 | 1,2 |
| Jun | 115 | 7 | 1 | --- | --- | | --- | --- | |
| Jul | --- | --- | | --- | --- | | --- | --- | |
| Aug | --- | --- | | --- | --- | | --- | --- | |
| Sep | --- | --- | | --- | --- | | --- | --- | |
| Oct | --- | --- | | --- | --- | | --- | --- | |
| Nov | 114 | 2 | 1 | --- | --- | | --- | --- | |
| Dec | 119 | 3 | 1 | --- | --- | | --- | --- | |
| Total days | | 28 | | | 11 | | | 10 | |
| | 2017 | | | 2016 | | | 2015 | | |
| MONTH | MAX % TDG | DAYS | REASON | MAX % TDG | DAYS | REASON | MAX % TDG | DAYS | REASON |
| Jan | --- | --- | | --- | --- | | --- | --- | |
| Feb | 114 | 3 | 1 | --- | --- | | --- | --- | |
| Mar | 121 | 18 | 1,2 | 112 | 1 | 1 | --- | --- | |
| Apr | 118 | 11 | 1,2 | 113 | 3 | 1,2 | --- | --- | |
| May | 117 | 16 | 1,2 | 114 | 11 | 1,2 | --- | --- | * |
| Jun | --- | --- | | --- | --- | | --- | --- | |
| Jul | --- | --- | | --- | --- | | --- | --- | |
| Aug | --- | --- | | --- | --- | | --- | --- | |
| Sep | --- | --- | | --- | --- | | --- | --- | |
| Oct | --- | --- | | 117 | 9 | 1,2 | --- | --- | |
| Nov | 117 | 5 | 1 | 122 | 15 | 1,2 | --- | --- | |
| Dec | 119 | 2 | 1 | --- | --- | | 124 | 20 | 1 |
| Total days | | 55 | | | 39 | | | 20 | |
| Notes: | An exceedance is considered any percent of Total Dissolved Gas greater than Oregon Standard of 110%. TDG data measurements began in May 2015 downstream of Foster Dam. | | | | | | | | |
| [ * ] | TDG sensor installed | | | | | | | | |
| [ 1 ] | Spill | | | | | | | | |
| [ 2 ] | Unit Out of Service (OOS) | | | | | | | | |

**Figure 3.5-46. Foster Total Dissolved Gas Exceedances greater than the Oregon State Standard of 110% Saturation (hourly), Measured near, 2015 – 2020, and including the Maximum Exceedance Value, Number of Days with Hourly Exceedances, and the Reason for Exceeding the State Standard.**

### *3.5.1.2.3 McKenzie Sub-basin*

The operation of Cougar Dam can lead to TDG exceedances above the state water quality standards when water is released through the regulating outlets of the dam. TDG is monitored at the USGS gaging station (CGRO) below Cougar Reservoir near Rainbow, Oregon (Figure 3.5-1). TDG is not monitored below Blue River Dam.

In 2006, the USACE conducted a two-day spill operation to study regulating outlets and powerhouse variable outflow discharges and TDG response (USACE 2007, *Draft*). The study measured TDG at 5 locations below Cougar Dam and one location in the forebay of Cougar Dam. Site locations were on the right bank of the powerhouse, right bank in the regulating outlet channel, right bank 590.5 ft (180m) below the confluence of powerhouse and regulating outlet releases, right bank adjacent to the USGS gage, right bank 2.8 mi (4.5 km) downstream of

Cougar Dam. The study concluded TDG was higher in the regulating outlet channel with flows higher than 575 cfs producing TDG above the state water quality standard (110%). Degassing and mixing of turbine and regulating outlet releases enabled TDG saturation to decrease downstream.

A compilation of TDG exceedances from 2012 to 2020 is provided with explanations (Figure 3.5-47). For instance, in April 2017 TDG levels reached 117% for 25 days due to spill and maintenance operations. The USACE has updated TDG regression equations for tailwaters below Cougar Dam (and Big Cliff, Foster, and Dexter dams) using data from 2011 to 2020. These equations, based on the SYSTDG formulas used in the Columbia River system, will assist in real-time Willamette Project operations, and allow a quantified comparison of TDG resulting from operations in the Willamette Valley PEIS.

| | 2020 | | | 2019 | | | 2018 | | |
|---|---|---|---|---|---|---|---|---|---|
| **MONTH** | **MAX % TDG** | **DAYS** | **REASON** | **MAX % TDG** | **DAYS** | **REASON** | **MAX % TDG** | **DAYS** | **REASON** |
| Jan | 120 | 16 | 1 | 115 | 13 | 1 | 117 | 2 | 1 |
| Feb | --- | --- | | --- | --- | | --- | --- | |
| Mar | --- | --- | | --- | --- | | --- | --- | |
| Apr | 114 | 3 | 1 | 113 | 2 | 1 | --- | --- | |
| May | --- | --- | | 117 | 12 | 1 | 116 | 12 | 1,2 |
| Jun | --- | --- | | --- | --- | | --- | --- | |
| Jul | --- | --- | | --- | --- | | --- | --- | |
| Aug | --- | --- | | --- | --- | | --- | --- | |
| Sep | 114 | 2 | 1 | --- | --- | | --- | --- | |
| Oct | --- | --- | | --- | --- | | --- | --- | |
| Nov | --- | --- | | --- | --- | | --- | --- | |
| Dec | 116 | 12 | 1 | --- | --- | | --- | --- | |
| **Total days** | | 33 | | | 27 | | | 14 | |
| | **2017** | | | **2016** | | | **2015** | | |
| **MONTH** | **MAX % TDG** | **DAYS** | **REASON** | **MAX % TDG** | **DAYS** | **REASON** | **MAX % TDG** | **DAYS** | **REASON** |
| Jan | --- | --- | | 120 | 19 | 1,2 | --- | --- | |
| Feb | --- | --- | | 119 | 29 | 1,2 | --- | --- | |
| Mar | 117 | 4 | 1 | 117 | 3 | 1,2 | --- | --- | |
| Apr | 117 | 25 | 1,2 | --- | --- | | --- | --- | |
| May | 117 | 31 | 1,2 | --- | --- | | --- | --- | |
| Jun | 114 | 5 | 1,2 | --- | --- | | --- | --- | |
| Jul | --- | --- | | --- | --- | | --- | --- | |
| Aug | --- | --- | | --- | --- | | --- | --- | |
| Sep | --- | --- | | --- | --- | | --- | --- | |
| Oct | --- | --- | | 112 | 4 | 1,2 | --- | --- | |
| Nov | 117 | 7 | 1 | 115 | 10 | 1,2 | 113 | 1 | 1 |
| Dec | --- | --- | | 117 | 21 | 1,2 | 119 | 20 | 1,2 |
| **Total days** | | 72 | | | 86 | | | 21 | |
| | **2014** | | | **2013** | | | **2012** | | |
| **MONTH** | **MAX % TDG** | **DAYS** | **REASON** | **MAX % TDG** | **DAYS** | **REASON** | **MAX % TDG** | **DAYS** | **REASON** |
| Jan | --- | --- | | --- | --- | | --- | --- | |
| Feb | --- | --- | | --- | --- | | --- | --- | |
| Mar | 113 | 1 | 1 | --- | --- | | --- | --- | |
| Apr | 113 | 1 | 1 | --- | --- | | --- | --- | |
| May | 116 | 5 | 1 | 112 | 3 | 1 | 114 | 1 | * 1 |
| Jun | 112 | 1 | 1 | --- | --- | | 114 | 16 | 1 |
| Jul | --- | --- | | --- | --- | | 112 | 6 | 1 |
| Aug | 111 | 1 | 1 | --- | --- | | 112 | 2 | 1 |
| Sep | --- | --- | | 113 | 1 | 1 | 111 | 1 | 1 |
| Oct | --- | --- | | --- | --- | | --- | --- | |
| Nov | 114 | 3 | 1 | 115 | 4 | 1 | 119 | 17 | 1 |
| Dec | --- | --- | | --- | --- | | 117 | 14 | 1 |
| **Total days** | | 12 | | | 8 | | | 57 | |
| **Notes:** | An exceedance is considered any percent of Total Dissolved Gas greater than Oregon Standard of 110% (>110.5%). TDG data measurements began in May 2012 downstream of Cougar Dam. | | | | | | | | |
| **[ * ]** | TDG sensor installed | | | | | | | | |
| **[ 1 ]** | Spill | | | | | | | | |
| **[ 2 ]** | Unit Out of Service (OOS) | | | | | | | | |

**Figure 3.5-47. Cougar Total Dissolved Gas Exceedances greater than the Oregon State Standard of 110% Saturation (hourly), Measured near, 2012 - 2020. Including the Maximum Exceedance Value, Number of Days with Hourly Exceedances, and the Reason for Exceeding the State Standard.**

#### *3.5.1.2.4 Middle Fork Sub-basin*

Since 2015 the Middle Fork Willamette River downstream of Dexter and Lookout Point Dams have been monitored for TDG (Figure 3.5-48). When outflows exceed the capacity of Lookout Point Dam's powerhouse, the spillway is used to pass the excess flow. This can lead to TDG exceedances above state water quality standards (110%) downstream.

The USACE conducted a TDG study from August 2012 until May 2013 at 12 sites in the Middle Fork Willamette River (Figure 3.5-48; USACE 2014). During the study Hills Creek Reservoir did not produce TDG levels (percent saturation) above the state criteria of 110% (Figure 3.5-49). The forebay of Lookout Point did not produce elevated TDG (>110%), however discharge from the regulating outlet, spillway, and powerhouse (backwater effect from spillway) resulted in TDG above 110% (Figure 3.5-50). Dexter Reservoir forebay TDG concentrations exceeded 110% when the Lookout Point spillway TDG concentrations were also exceeding the state standard. Comparable results were observed between the Dexter powerhouse and forebay concentrations. Flow through the Dexter spillway can increase TDG (>110%) and is dependent on spillway to powerhouse flow (Figure 3.5-51). The study concluded that excess TDG, generated from Lookout Point and Dexter Dams, generally dissipates to background levels within approximately 8 miles downstream of the Fall Creek confluence on the Middle Fork Willamette River. Currently, TDG is not monitored at Hills Creek, Lookout Point or Fall Creek.

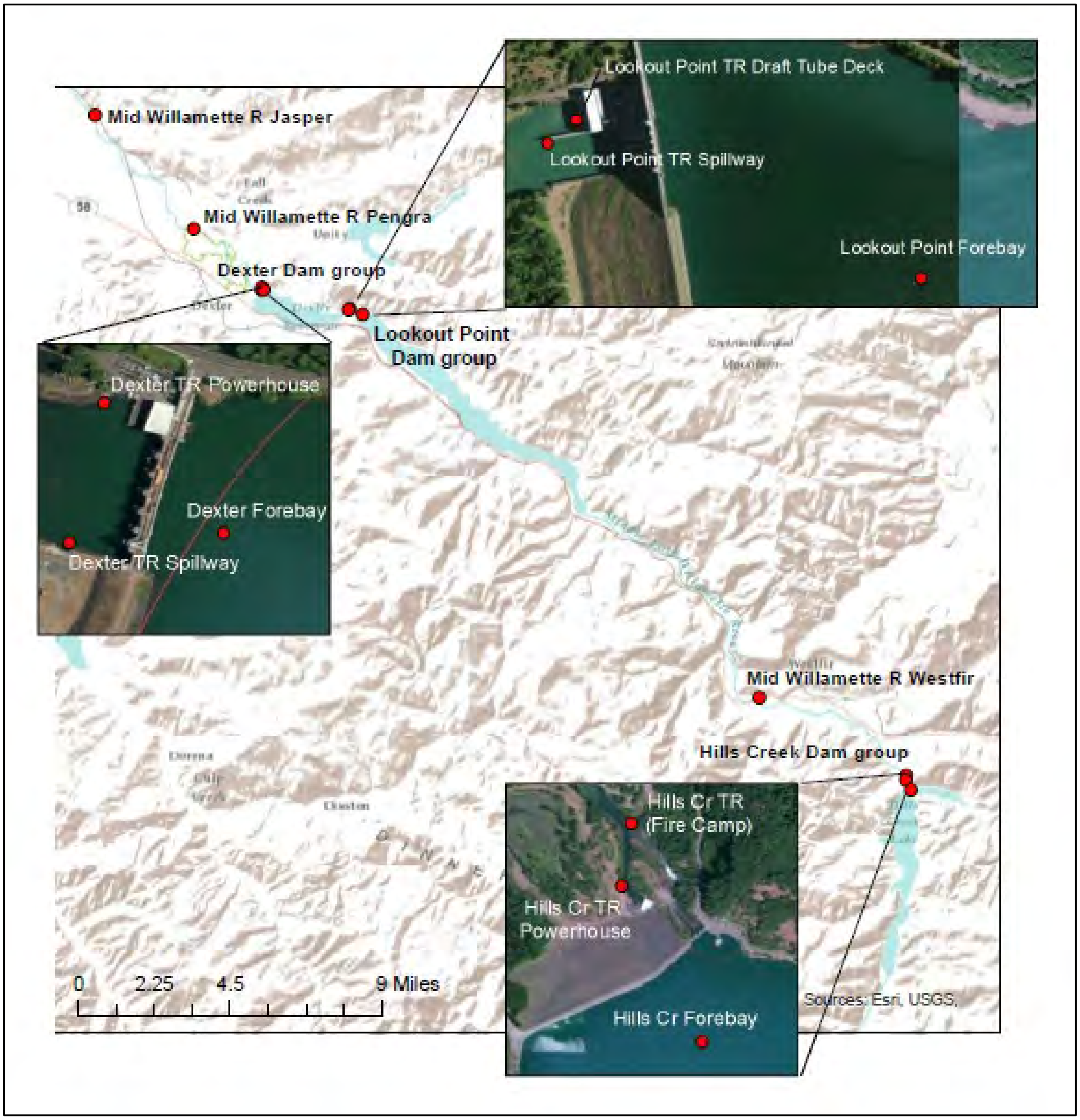



**Figure 3.5-48. Sampling locations for 2012 – 2013 Middle Fork Willamette TDG study (USACE 2014).**

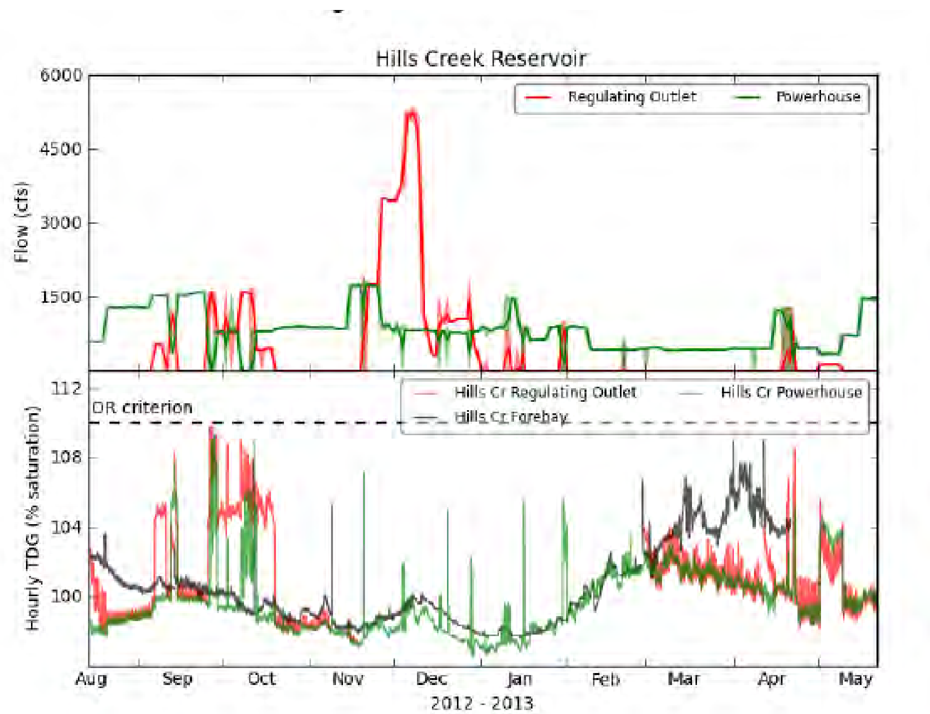



**Figure 3.5-49. Hills Creek Reservoir Operations and TDG Measurements, 2012 -2013 (USACE 2014)**

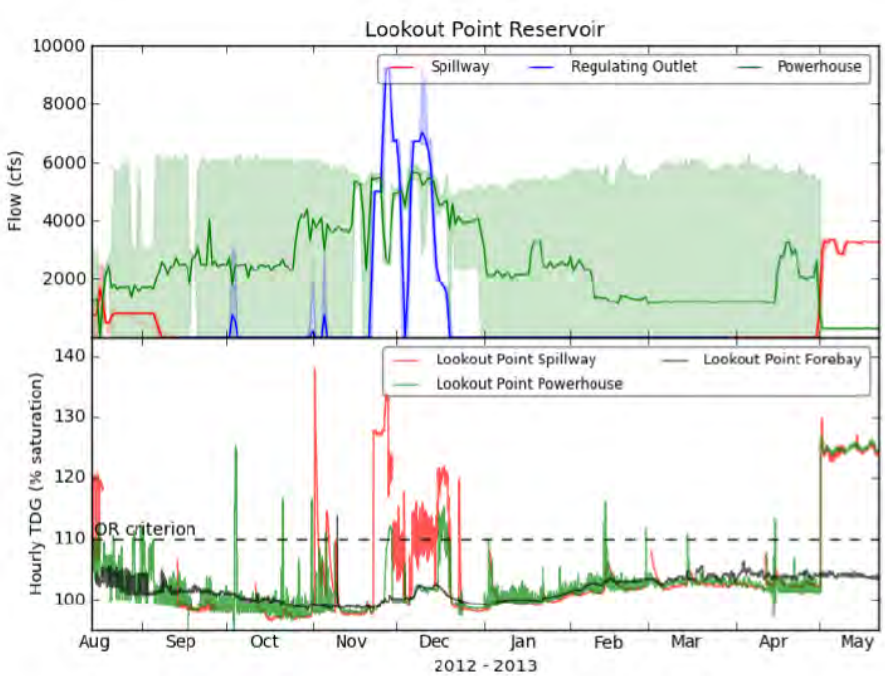



**Figure 3.5-50. Lookout Point Reservoir Operations and TDG Measurements, 2012 – 2013 (USACE 2014)**

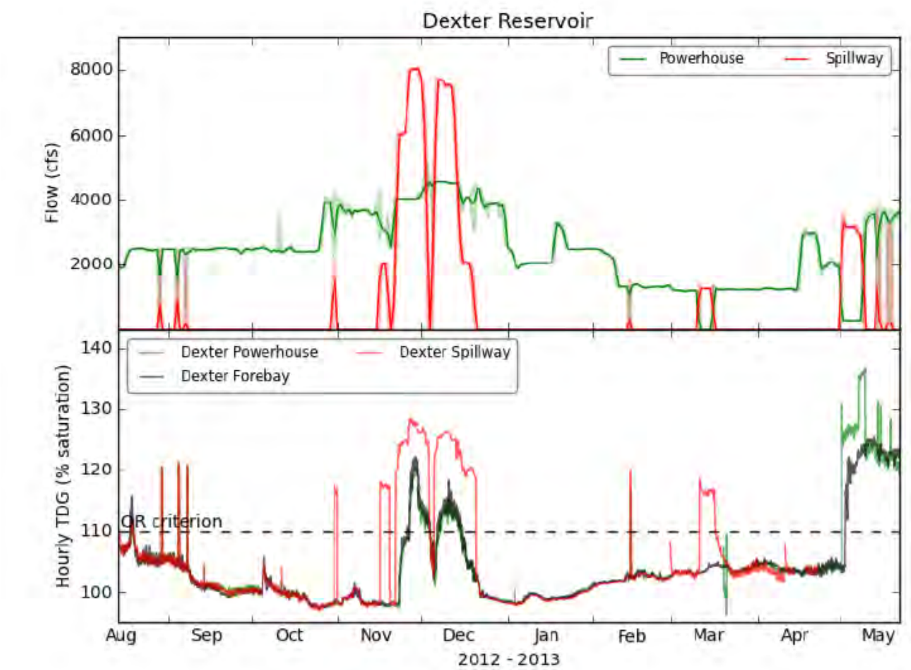



**Figure 3.5-51. Dexter Reservoir Operations and TDG Measurements, 2012 -2013 (USACE 2014)**

A compilation of TDG exceedances from 2015 to 2020 is provided with explanations (Table 3.5-52). For instance, in March 2017 TDG levels reached 118% for 18 days due to spill operations. The USACE has updated TDG regression equations for tailwaters below Dexter Dam (and Big Cliff, Foster, and Cougar Dam) using data from 2011 to 2020. These equations, based on the SYSTDG formulas used in the Columbia River system, will assist in real-time Willamette Project operations, and allow a quantified comparison of TDG resulting from operations in the Willamette Valley PEIS.

| | 2020 | | | 2019 | | | 2018 | | |
|---|---|---|---|---|---|---|---|---|---|
| MONTH | MAX % TDG | DAYS | REASON | MAX % TDG | DAYS | REASON | MAX % TDG | DAYS | REASON |
| Jan | 113 | 4 | 1 | 114 | 12 | 1 | --- | --- | |
| Feb | 112 | 1 | 1 | --- | --- | | --- | --- | |
| Mar | 112 | 1 | 1 | --- | --- | | --- | --- | |
| Apr | 112 | 6 | 1 | 119 | 23 | 1,2 | --- | --- | |
| May | --- | --- | | 116 | 31 | 1,2 | 114 | 3 | 1 |
| Jun | 111 | 1 | 1 | 116 | 25 | 1,2 | --- | --- | |
| Jul | --- | --- | | 112 | 2 | 1 | --- | --- | |
| Aug | --- | --- | | --- | --- | | --- | --- | |
| Sep | 113 | 3 | 1 | --- | --- | | --- | --- | |
| Oct | --- | --- | | --- | --- | | --- | --- | |
| Nov | --- | --- | | --- | --- | | --- | --- | |
| Dec | --- | --- | | --- | --- | | --- | --- | |
| Total days | | 16 | | | 93 | | | 3 | |
| | 2017 | | | 2016 | | | 2015 | | |
| MONTH | MAX % TDG | DAYS | REASON | MAX % TDG | DAYS | REASON | MAX % TDG | DAYS | REASON |
| Jan | --- | --- | | 111 | 1 | 1 | --- | --- | |
| Feb | --- | --- | | --- | --- | | --- | --- | |
| Mar | 118 | 18 | 1 | 112 | 10 | 1,2 | --- | --- | |
| Apr | 115 | 30 | 1 | --- | --- | | --- | --- | |
| May | --- | --- | | --- | --- | | --- | --- | * |
| Jun | --- | --- | | --- | --- | | 111 | 12 | 1,2 |
| Jul | --- | --- | | --- | --- | | --- | --- | |
| Aug | --- | --- | | --- | --- | | --- | --- | |
| Sep | --- | --- | | --- | --- | | --- | --- | |
| Oct | --- | --- | | --- | --- | | --- | --- | |
| Nov | --- | --- | | --- | --- | | --- | --- | |
| Dec | --- | --- | | --- | --- | | 115 | 7 | 1 |
| Total days | | 48 | | | 11 | | | 19 | |
| Notes: | An exceedance is considered any percent of Total Dissolved Gas greater than Oregon Standard of 110%. TDG data measurements began in May 2015 downstream of Dexter Dam. | | | | | | | | |
| [ * ] | TDG sensor installed | | | | | | | | |
| [ 1 ] | Spill | | | | | | | | |
| [ 2 ] | Unit Out of Service (OOS) | | | | | | | | |

**Figure 3.5-52. Dexter Total Dissolved Gas Exceedances greater than the Oregon State Standard of 110% Saturation (hourly), Measured near, 2015 - 2020. Including the Maximum Exceedance Value, Number of Days with Hourly Exceedances, and the Reason for Exceeding the State Standard.**

### *3.5.1.2.5 Coast Fork and Long Tom Sub-basins*

TDG is not monitored at Cottage Grove, Dorena and Fern Ridge Reservoirs. As stated in the 2008 BiOp: "The ODEQ 2004/2006 Integrated Report database does not identify any streams in the Coast Fork Willamette sub-basin that are water quality limited due to high TDG concentrations (ODEQ 2006b). However, a juvenile Salmonid study final report done for Dorena Lake Dam Hydroelectric Project by the firm Symbiotics (2005) measured TDG in the deep bottom waters of Dorena Reservoir as well as in the Row River just below the existing outlet gates at Dorena Dam. TDG levels deep in the reservoir exceeded ODEQ's 110% maximum saturation standard during February and March. Symbiotics also concluded that aeration through the dam's outlet gates causes TDG below the dam to exceed DEQ's standard in July and August. There are no other data on TDG concentrations in areas of the Coast Fork Willamette sub-basin used for listed anadromous salmonids" (NMFS 2008).

### *3.5.1.3 Harmful Algae Blooms or Cyanobacteria*

Harmful Algae Blooms (HABs) or blue-green algae are cyanobacteria that are commonly found in aquatic environments. Cyanobacteria occur naturally in aquatic environments and have the capability to produce toxins (cyanotoxins). Factors such as nutrient inputs, like nitrogen and phosphorous, and temperature can increase the likelihood of growth. Nutrients inputs can come from the natural environment or introduced as source pollution into waters. Cyanotoxins can affect the central nervous system or kidney/liver functions in humans, pets and livestock.

The Oregon Health Authority (OHA) implements cyanobacteria toxin guidelines and threshold levels for recreation and drinking waters for the public (OHA 2019). Information provided by OHA with current and archived algae bloom recreational advisory includes Willamette Valley reservoirs (Figure 3.5-53; OHA 2020). When USACE staff collect water samples that are sent for toxin analysis, OHA is notified if levels are above the toxin threshold. OHA then assesses the need for a public advisory for a particular water body.

Since 2005, OHA has been posting advisories based on sample results that exceed the cyanotoxin threshold levels (Figure 3.5-54). As shown in Figure 3.5-54 the criteria has evolved from 2005 to present. For instance, presently if Microcystin exceeds 8µg/L then OHA will post an advisory for the water body. The USACE has placed informational signage near boat ramp areas to bring awareness to the public. In addition, USACE staff review Landsat satellite imagery of reservoirs for potential algae bloom activity which is provided on the USACE Water Management Water Quality Reports public website (USACE 2022).

| Willamette Valley Basin Reservoirs | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Duration in Days of Harmful Algae Bloom Advisories by OHA (blank if none) | | | | | | | | | | | | | | | | | |
| **Reservoir** | **2020** | **2019** | **2018** | **2017** | **2016** | **2015** | **2014** | **2013** | **2012** | **2011** | **2010** | **2009** | **2008** | **2007** | **2006** | **2005** | **2004** |
| **Detroit** | | | 50 | 14 | | 6 | | | | | | | | 14 | | | |
| **Big Cliff** | | | 21 | | | | | | | | | | | | | | |
| **Foster** | | | | | | | | | | | | | | | | | |
| **Green Peter** | | | | | | | | | | | | | | | | | |
| **Fern Ridge** | | | | | | | | 125 | 54 | | | | | | | | |
| **Blue River** | | | | | | | | | | | 25 | | | | | | |
| **Cougar** | | | | | | | | | | 35 | | | | | | | |
| **Fall Creek** | | | | | | | | | | 101 | | | | | | | |
| **Dexter** | | | | | | | | 78 | 95 | 56 | 40 | 46 | 34 | | | | |
| **Lookout Point** | | | | | | | | | | | | | | | | 52 | |
| **Hills Creek** | | | | | | | | | | | | 58 | 62 | 26 | 20 | 65 | |
| **Cottage Grove** | | | | | | | | | | | | | | | | | |
| **Dorena** | | | 9 | | | | | 61 | 84 | 35 | 24 | 71 | 33 | | | | |

**Figure 3.5-53. Oregon Health Authority (OHA) algae bloom advisory by duration of days in Willamette Reservoirs based on toxin level guidance.**

OHA: http://public.health.oregon.gov/HealthyEnvironments/Recreation/HarmfulAlgaeBlooms/Pages/Blue-GreenAlgaeAdvisories.aspx

| | OHA Algae Bloom Toxin Threshold Levels in Recreational Waters | | | |
|---|---|---|---|---|
| Year Implemented | Cyanotoxins (µg/L) | | | |
| | Microcystin | Cylindrospermopsin | Anatoxin-a | Saxitoxin |
| 2019 to present | 8 | 15 | 15 | 8 |
| 2018 | 4 | 8 | 8 | 4 |
| 2016 | 10 | 20 | 20 | 10 |
| 2015 | 10 | 6 | 20 | 10 |
| 2012 | 10 | 6 | 20 | 100 |
| 2006 | ≥ 8 | | When detected | |
| 2005 | Cell density: 100,000 cells/mL for total toxigenic cyanobacteria or 40,000 cells/mL for *Microcystis* or *Planktothrix* | | | |

**Figure 3.5-54. Oregon Health Authority (OHA) Toxin Level Thresholds in Recreational Waters by Year implemented, from 2005 until present**

### *3.5.1.3.1 North Santiam Sub-basin*

Cyanobacteria blooms occur frequently in Blowout and Heater Creek arms of Detroit Reservoir. Detroit Reservoir has been listed on the OHA algae bloom advisory in 2018, 2017, 2015 and 2007. Big Cliff Reservoir has been listed on the OHA advisory in 2018 (Figure 3.5-53).

In May 2018 the City of Salem public water utility analyzed routine water samples within Detroit Reservoir, which resulted in high cyanotoxin levels. The City of Salem supplies drinking water daily to approximately 197,000 customers and draws water within the North Santiam River (City of Salem 2020). The City of Salem's water intake is located at Geren Island which is approximately 28 miles downstream of Detroit Reservoir. Due to the public health concern, water temperature control operations were delayed in 2018 for three weeks. During this event, rigorous field monitoring and sampling occurred by USACE and City of Salem until toxin levels were reduced to below the OHA toxin threshold (Figure 3.5-54). The dominant observed species was *Dolichospermum sp. (*previously *Anabaena sp.)* which can produce liver and nerve toxins.

Further research is needed to determine factors that assist in toxin production and toxin suppression. The City of Salem conducts routine monitoring and, in collaboration with the USACE and USGS, currently has a water quality platform deployed in Detroit Reservoir studying factors that may increase algae growth. The US Forest Service also collects water samples for cyanobacteria toxin analysis. In the future, these algae blooms may persist if nutrient inputs to the Reservoir remain the same or increase.

### *3.5.1.3.2 South Santiam Sub-basin*

There have been no known toxic algae blooms present in Green Peter and Foster Reservoirs; as such, no harmful algae bloom advisories have been issued by OHA (Figure 3.5-53). Species such as *Anabaena* sp., *Aphanizomenon* sp., and *Microcystis* sp. have been identified from water samples collected during the summer and early fall.

### *3.5.1.3.3 McKenzie Sub-basin*

Both Cougar and Blue River Reservoir have experienced harmful algae blooms (cyanobacteria). In general, water samples collected at these reservoirs have identified *Anabaena* sp. and *Aphanizomenon* sp. during the summer and early fall. These species have been known to produce toxins. Toxins produced by harmful algae blooms, such as Microcystin and Cylindrospermopsin, have been identified within Blue River and Cougar reservoirs, which prompted the OHA to include them on the advisory list in 2010 and 2011 (Figure 3.5-53).

USACE has posted algae bloom information signage at boat ramps near the reservoirs. When USACE staff collect water samples that are sent for toxin analysis, OHA is notified if levels are above the toxin threshold. Advisories are posted on the OHA Cyanobacteria (Harmful Algae) Blooms website and further water testing is conducted until the toxin levels are reduced below the OHA toxin threshold (OHA 2022). The Eugene Water Electric Board (EWEB) provides service to approximately 200,000 customers (includes electricity and water) and conducts routine sampling and laboratory analysis of water collected within both reservoirs and along the McKenzie River (EWEB 2017). The water intake for EWEB is located on River Mile 15 on the McKenzie River (OHA 2012). The USACE is collaborating with USGS, the City of Salem and EWEB to collect water quality information utilizing equipment housed on a floating platform within Cougar Reservoir. This study hopes to analyze data within Cougar Reservoir and compare with Detroit Reservoir results for algae bloom signatures and potential inputs.

### *3.5.1.3.4 Middle Fork Willamette Sub-basin*

Harmful algae bloom advisories have been documented for all four reservoirs, most recently at Dexter Reservoir in 2013 for 78 days (Figure 3.5-53). Fall Creek Reservoir was listed on the OHA advisory in 2011 for 101 days, Hills Creek for 58 days in 2009 and Lookout Point for 52 days in 2005. Historically, the dominant species identified include *Gloeotrichia* sp., *Dolichospermum* sp. and *Aphanizomenon* sp. which may produce Microcystin and Cylindrospermopsin toxins.

USACE contracted Portland State University to produce a CE-Qual-W2 model utilizing physical parameters and potential algae bloom response within Dexter Reservoir (Cervarich et al. 2020). Analysis included scenarios for structural changes (power intake, Lowell Covered Bridge, and curtain weir at bridge) and climate change. Results showed the simulated algae bloom was eliminated with structural changes and intensified with climate change scenarios. In the future, these results may be used to assist reservoir operations and management decisions. When USACE staff collect water samples that are sent for toxin analysis, OHA is notified if levels are above the toxin threshold. The USACE posts informational signage about algae blooms at reservoir boat ramps.

### *3.5.1.3.5 Coast Fork and Long Tom Sub-basins*

Cottage Grove, Dorena, and Fern Ridge Reservoirs have experienced algae blooms; however, not all blooms have been toxic and listed on the OHA advisory (Figure 3.5-53). Cottage Grove Reservoir has not been under an OHA Cyanotoxin advisory, although the USACE has collected samples in 2016 and 2019. Dorena Reservoir has been listed on the OHA advisory in 2018 for 9 days and Fern Ridge was last under an advisory for 125 days in 2013. Observed species in these reservoirs include *Gloetrichia* sp., *Aphanizomenon* sp., *Dolichospermum* sp., and *Microcystis* sp. The most common toxins have been Microcystin and Cylindrospermopsin which may produce nerve and liver damage. When USACE staff collect water samples that are sent for toxin analysis, OHA is notified if levels are above the toxin threshold. Lane County Parks also collects water samples analysis as necessary. USACE posted information signage at the reservoir boat ramps to educate the public about algae blooms.

### *3.5.1.4 Turbidity*

Increased turbidity levels can arise during storm events or maintenance operations of dams. During storm events bank erosion can increase sediment transport causing elevated turbidity. Turbidity monitoring is conducted ad-hoc and as necessary to ensure sediment load is minimal. At this time turbidity monitoring is not conducted year-round. As per OAR 340-041-0036:

> “No more than a ten percent cumulative increase in natural stream turbidities may be allowed, as measured relative to a control point immediately upstream of the turbidity causing activity”.

#### *3.5.1.4.1 Middle Fork Willamette Sub-basin*

At Fall Creek Reservoir, a deep reservoir drawdown to facilitate volitional downstream fish passage has occurred since 2012. Model results of drawdowns and influences on juvenile UWR spring Chinook salmon show the drawdown has minimal impacts to juvenile UWR spring Chinook salmon and incomplete refill may also reduce growth potential (Johnson et al. 2016). A USGS study, USACE-funded, was conducted at Fall Creek Lake to monitor and evaluate suspended sediment transport, bedload and dissolved oxygen in 2012 -2013. A calculated suspended sediment budget for 72 days concluded 16,300 tons of deposition occurred in the reaches of Fall Creek and the Middle Fork Willamette River (Schenk et al. 2014). The USACE has also funded USGS to conduct suspended sediment, turbidity, and DO studies for years 2012 – 2017. In general, turbidity levels increase as reservoir drawdown occurs (Figure 3.5-55). A summary was presented at the 2019 Willamette Fisheries Science Review on March 12 -14, 2019. The USGS will publish the report in 2021.

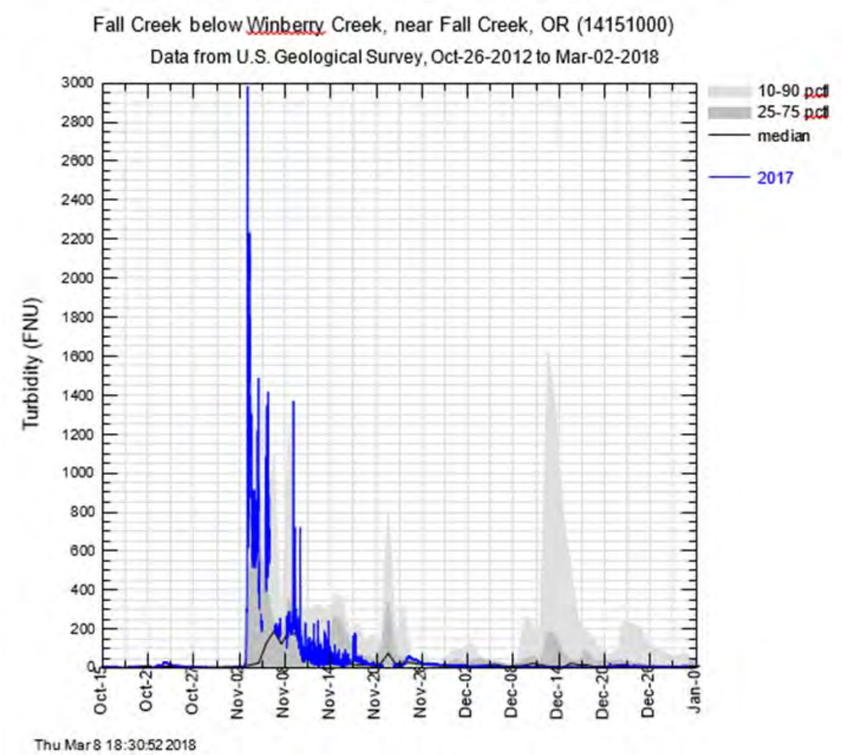



**Figure 3.5-55. Turbidity measured by USGS downstream of Fall Creek Reservoir during deep drawdown, 2012 – 2017.**

### *3.5.1.5 Mercury*

As discussed in section 1.8 the Willamette Valley System reservoirs operate for authorized purposes and follow a rule curve (Figure 1.8-3). Reservoir water elevations follow the rule curve based on operational requirements and time of year. A reservoir water drawdown operation for flood risk management can expose lakebed sediments. As the reservoir refills sediments will be covered with water and organic matter. The drying and rewetting of sediments from changing water levels may increase the methylation of mercury (Willacker et. al 2016; Eckley et. al. 2015).

Mercury can come from naturally occurring process such as deposits within volcanic rock or man-made processes such as atmospheric deposition and mining activities (Park et al. 1997; Ambers et al. 2001; Hammerschmidt et al. 2006). Main forms of Mercury are elemental, inorganic, and organic. Atmospheric deposited Mercury (elemental) can be converted to Methyl Mercury by microbial groups that are potential Hg methylators (Gustin et al. 2020). Biomagnification of mercury has been studied in the aquatic food web from plankton to fish species (Kidd et. al 2012; Hall et. al. 1997). Methyl Mercury (MeHg) is an organic form of Mercury that has harmful health effects for humans and wildlife (Chételat et al. 2020; Willacker et. al. 2020; Clarkson and Magos 2006; Scheuhammer et al. 2007). Methyl Mercury is a neurotoxin and consuming fish that has MeHg in their tissues is a main exposure for humans and wildlife (Hall et al. 1997; Cusack et al. 2017; Jackson et al. 2016; Sandheinrich et al. 2011). Federal and state agencies have advisories and guidelines for fish consumption limits for humans (EPA and FDA 2022; OHA 2022). As of February 4, 2021, the ODEQ and EPA have issued a revised 2019 Willamette Basin Mercury TMDL; the previous TMDL was issued in 2006.

##### *3.5.1.5.1 Coast Fork and Long Tom Sub-basins*

Mercury has been identified and studied within Cottage Grove and Dorena Reservoirs (Park et al. 1997; Ambers et al. 2001; Curtis 2003; Curtis et al. 2013; Hope et al. 2005; Eagles-Smith et al. 2016). Cottage Grove Reservoir has mercury contamination originating from the Black Butte Mine (Environmental Protection Agency (EPA) Superfund National Priorities List in 2010), which is approximately 15 km upstream (Eckley et al.2015). The Black Butte Mine was utilized for cinnabar mining to produce quicksilver (liquid mercury) and ceased operations in the late 1960’s. However, mercury contaminated soil from Black Butte has been transported downstream and deposited within Cottage Grove reservoir.

Anaerobic bacteria are able to convert mercury to Methylmercury, which can be released and accumulate in aquatic organisms and fish (Eckley et al. 2017). The EPA has conducted recent cleanup of the mine area in 2018 and 2020 (EPA 2020). In 2021, the EPA has planned sampling to assess conditions within Cottage Grove Reservoir and previous Black Butte cleanup actions. Signs are posted by OHA at the reservoir boat ramps to educate the public of fish consumption guidelines.

Dorena reservoir has also been found to contain mercury due to mining activities from the Bohemia Mining District, located 30 km upstream (Hygelund 2000). Although, the mining activities conducted were different from the Black Butte Mine in that quicksilver was utilized for gold and silver recovery. These mining activities resulted in lower contamination levels into Dorena Reservoir (Ambers et al. 2001). Signs are posted by the OHA at the reservoir boat ramps to educate the public of fish consumption guidelines.

#### ***3.5.1.6 Sediment Quality***

Sediment is defined as mineral and/or organic material that is eroded, transported, and deposited by wind, water, and/or glacial erosion. Sediment can be composed of clay, silt, sand, gravel, and larger rocks as well as organic matter derived from plants, animals, fungi, etc.

When wetted, sediment composed of fine-grained mineral particles (silts and clays) and organic matter are capable of adsorbing (bind/ hold) ions. They are also able to adsorb contaminants. Manmade contaminants such as pesticides and polychlorinated biphenyls (PCBs) and naturally occurring contaminants (generated from the erosion of volcanic rocks) are hydrophobic (“water-fearing”) and are adsorbed and sequestered in the sediment rather than readily dissolving in water. As such, contaminants sequestered in the sediment do not typically impact the water quality in the overlying water column unless they occur at very high concentrations.

Once adsorbed to the sediment, contaminants can persist in the sediment for years, long after they are no longer detectable in water. Although many of these manmade chemicals were banned decades ago, they are still found in lake and stream bed sediment, sometimes at concentrations high enough to be a risk to aquatic organisms. For additional information on sediment see Section 3.3.

In the Northwest Region, the *Sediment Evaluation Framework for the Pacific Northwest* (SEF) is used to evaluate sediment quality in the states of Oregon, Washington, and Idaho (NWRSET, 2018). This guidance was developed for use in these three states by federal agencies (USACE-Northwestern Division, Environmental Protection Agency – Region 10, National Marine Fisheries Service, and US Fish and Wildlife Service), the state water quality agencies (Oregon Department of Environmental Quality, Washington Department of Ecology, and Idaho Department of Environmental Quality), and the Washington Department of Natural Resources.

Per the SEF, the area of interest is identified, and sediment sampling objectives are defined. Sediment samples are collected from the area of interest and sent to laboratories for analysis. Up to nearly 60 contaminants are analyzed, and the bulk sediment concentrations measured by the laboratories are compared to freshwater thresholds ("screening levels") that are protective of benthic and epibenthic fauna.

The sediment chemical screening levels presented in the SEF are primarily used to evaluate federal and non-federal navigational dredging projects. However, the SEF thresholds may also be used to assess the quality of sediments stored behind reservoirs or in other projects in which sediments may be excavated and discharged into wetlands or waterways.

Sediment in the 11 of the 13 WVS reservoirs has been sampled and analyzed to determine the presence or absence of sediment-borne contaminants. Due to resourcing constraints Blue River and Hills Creek Reservoirs have not been sampled, no future sampling is anticipated. The EPA collected sediment samples from Cottage Grove Reservoir in 2021 relating to the Black Butte Mine clean up (Section 3.5.1.5) the results are pending.

A summary of sampling that has occurred in the reservoirs (between 2002 and 2021) appears in Table 3.5-6. Sediments in nearly all reservoirs have been analyzed for grain size distribution, total organic carbon content, heavy metals, and organochlorine pesticides. The metals analysis is performed due to the volcanic nature of the soils contributing sediment to the reservoirs and the occurrence of mines above some of the reservoirs. The pesticides analysis was typically performed due to the known history of aerial application to control forest pest species. Analysis for other contaminant groups (semivolatile organic compounds [including polynuclear aromatic hydrocarbons, phthalates, phenols, and miscellaneous extractable compounds] and polychlorinated biphenyls) was performed if there was reason to believe those chemicals might be present due to a nearby source.

To date, none of the in-water sediment samples collected have shown contaminant concentrations above the regional SEF freshwater screening levels. Pesticides were detected in forested soils adjacent to Cougar Reservoir during the 2002 sediment sampling event; however, pesticides were not detected above the regional sediment quality guidelines in the reservoir sediments.

**Table 3.5-6. Summary of Sediment Sampling and Analysis at the 13 Willamette Valley Project Reservoirs, Willamette River Basin, Oregon**

| Sub-basin | WVP Facilities | Year Sampled | Parameters analyzed (no. samples) | Above SEF FW SLs? | Notes |
|---|---|---|---|---|---|
| North Santiam | Detroit | 2010 | Metals, PAHs, SVOCs, OC pesticides, PCBs (3 samples at RO) | No | Bis(2-ethylhexyl) phthalate (common in plastics) detected above the SEF FW SL, but dismissed as a laboratory-generated contaminant |
| | | 2013 | G.S., metals, OC pesticides (5 samples in pool) | No | |
| | Big Cliff | 2013 | G.S. | No | Sediment coarse-grained, so no chemical analysis was performed |
| South Santiam | Green Peter (Middle Santiam) | 2013 | G.S., metals, OC pesticides (8 samples) | No | |
| | Foster (South Santiam) | 2013 | G.S., metals, OC pesticides (4 samples) | No | |
| McKenzie | Cougar (South Fork McKenzie) | 2002 | G.S., metals, DDX, phthalates, PAHs (28 samples: 1 downstream, 2 upland upstream, 25 in pool) | No (in pool) No (downstrm) Yes (in upland) | Most samples coarse-grained; 17 samples submitted for DDX analysis. DDE and DDT concentrations in a upland sample collected upstream of reservoir exceeded the SEF FW SLs |
| | | 2012 | G.S., metals, OC pesticides (3 composite samples in pool) | No | |
| | Blue River | NOT SAMPLED | | | |
| Middle Fork Willamette | Hills Creek | NOT SAMPLED | | | |
| | Lookout Point | 2013 | G.S., metals, OC pesticides (7 samples in pool) | No | |
| | Dexter | 2013 | G.S., metals, OC pesticides (1 composite sample in pool) | No | |

| Sub-basin | WVP Facilities | Year Sampled | Parameters analyzed (no. samples) | Above SEF FW SLs? | Notes |
|---|---|---|---|---|---|
| Fall Creek | Fall Creek | 2012 | G.S., metals, OC pesticides (3 composite samples in pool) | No | |
| Long Tom | Fern Ridge | 2005 | G.S., metals, DDX, PCBs, PAHs (9 samples) | No | 9 samples total in pool; 4 along the dam face |
| Coast Fork Willamette | Dorena | 2017 | G.S., metals, OC pesticides (2 composite samples in pool) | No | Metals below SEF FW SLs; no pesticides detected |
| Row River | Cottage Grove | 2021 | G.S., metals | Results pending | Black Butte Mine Superfund Site upstream of Cottage Grove. EPA sampled reservoir sediment to determine contamination extent. |

Abbreviations: SEF FW SL = freshwater benthic toxicity screening levels from the 2018 *Sediment Evaluation Framework for the Pacific Northwest*; G.S. = grain size; Metals = Sb, As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Zn; DDX = DDT and DDD, DDE (DDT breakdown products); OC pesticides = organochlorine pesticides (DDX, chlordane compounds, aldrin, dieldrin, lindane); PAHs = polynuclear aromatic hydrocarbons; SVOCs = semivolatile organic compounds; PCBs = polychlorinated biphenyls

### 3.5.2 Environmental Consequences

Environmental consequences in relation to water quality parameters were compared between the No Action Alternative the action alternatives. The parameters, Water Temperature and Total Dissolved Gas (TDG) were modeled and described in the Methodology section below. Parameters such as, Turbidity, Harmful Algae Blooms, and Mercury were qualitatively described by Alternative utilizing information from the River Mechanics & Geomorphology, Hydrological Processes and Climate Change sections.

#### *3.5.2.1 Methodology*

Table 3.5-7 describes how water quality effects are designated. Further screening criteria flow charts are provided for water temperature and TDG. The water quality parameters are compared to the No Action Alternative for each Alternative.

##### *3.5.2.1.1 Water Temperature*

The model CE-QUAL W2 was utilized to simulate water temperatures at all sub-basins, except for the Coast Fork and Long Tom sub-basins for the years 2011, 2015, 2016. Each year represented a different climatological condition: wet year (2011), dry year (2015), and average year (2016), and average of the three years (2011,2015,2016). CE-QUAL-W2 reservoir water temperature model output was analyzed for each of the three calendar years in each reservoir and immediately downstream (Technical Appendix D). Inflow discharge, inflow water temperature, air temperature, barometric pressure, wind speed, wind direction, and gate-specific outflow data were used as inputs for each simulation.

To assess effects in each Alternative, the hourly water temperature below each dam was used in a calculation of the 7-day Average of the Daily Max (7dADM) water temperature. The 7dADM water temperature was then compared to the temperature targets at each location to assess effects in each alternative. As stated in OAR 340-041-0028 (4) the seven-day-average maximum temperature of a stream is utilized for life stages of fish species in determining temperature thresholds, for example UWR spring Chinook salmon, UWR steelhead, and bulltrout. Please refer to the Water Quality Technical Appendix D for more detailed information.

#### *3.5.2.1.2 TDG*

Available data from Detroit/Big Cliff, Green Peter/Foster, Lookout Point/Dexter, Hills Creek, and Cougar Dams was utilized to simulate TDG with the SYSTDG model. TDG measures under the action alternatives are proposed at these dams due to data availability from gages and not discussed at Fall Creek and Blue River. This model was adapted from the Columbia River System TDG model. SYSTDG is an empirical (data-driven) model depending primarily on spill outflow (non-turbine releases) and power outflow (turbine releases) at each dam. The period of record used by the RES-SIM modeling was applied to SYSTDG at the locations listed above for each alternative. Please refer to the Water Quality Technical Appendix D for further data formulas and results, such as boxplot figures of TDG by Alternative compared to the NAA.

The SYSTDG model output includes estimated TDG based on project operations and the annual number of days above 110% (Technical Appendix D). TDG results are compared to the State of Oregon water quality standards in the Oregon Administrative Record (OAR) 340-041-0031: "Except when stream flow exceeds the ten-year, seven-day average flood, the concentration of total dissolved gas relative to atmospheric pressure at the point of sample collection may not exceed 110% of saturation". Please refer to section 3.5.3 for explanation of TDG effects.

#### *3.5.2.1.3 Turbidity*

Description is qualitatively based on information provided in the River Mechanics and Geomorphology Chapter 3.3 and Technical Appendix C which includes potential for changes in sediment supply.

The Sediment Supply analysis assumes that sediment supply from rivers upstream of WVS projects, or tributaries to WVS impacted reaches that are not downstream of a WVS reservoir, is unchanged relative to the No Action Alternative (NAA). This metric estimates the potential for changes in sediment passing WVS projects relative to NAA (see section 3.3.2.1).

#### *3.5.2.1.4 Harmful Algae Blooms (HABs)*

Description is qualitatively based on information provided in the River Mechanics and Geomorphology Chapter 3.3 and Technical Appendix C for Head-of-Reservoir, Shoreline Exposure, Sediment Re-Entrainment or Bank Failure Potential and Climate Change Technical Appendix F.

The head-of-reservoir sediment mobilization metric is designed to indicate the potential for changes in sediment scour and deposition patterns in the most upstream portion of storage reservoirs as it may impact nutrient availability within sediments for algae. In dams that use large amounts of storage volume and operate over a wide range of elevations throughout the year, the transition from riverine to reservoir conditions can shift upstream and downstream considerable distances (see section 3.3.2.1). Head-of-reservoir sediment mobilization metric is utilized to describe potential nutrient availability within sediments entering the reservoir for algae.

Shoreline erosion of bank sediments along reservoir margins is a complex process that is influenced by the cumulative effects of: wave erosion, reservoir currents, precipitation runoff, freeze-thaw, soil properties, exposure, vegetation density and type. One commonly observed process is that during times of extended reservoir drawdown, exposed un-vegetated shoreline soils that were previously saturated are prone to erosion and slumping. The shoreline exposure metric was developed as a surrogate for shoreline erosion processes. This metric compares the number of days that the reservoir water surface spends at any elevation to identify change in shoreline exposure and indicate the potential for change in shoreline erosion in the WVS storage projects (see section 3.3.2.1). Shoreline erosion of bank sediment metric is utilized to describe potential nutrient availability within sediments for algae.

A separate potential source of sediment to the reservoir can come from bank erosion or bank failures within the reservoir itself. Drawdowns deeper than those historically experienced have the potential to re-suspend stored sediments or induce landslides (USACE, 2003) and introduce new sediment to the reservoir. The timing of these deep drawdowns is not correlated to reservoir inflow and are not fully captured in the Sediment Trap Efficiency metric. Deeper drawdowns are assumed to increase the potential for sediment re-entrainment and slope failure supplying additional suspended sediment to the reservoir. Whether this sediment would settle within the reservoir or pass downstream would depend on sediment quality and hydraulics within the reservoir (see section 3.3.2.1). Sediment Re-Entrainment or Bank Failure Potential metric is utilized to describe potential nutrient availability within sediments for algae.

#### *3.5.2.1.5 Mercury*

Description is qualitatively based on information provided in the River Mechanics and Geomorphology Chapter 3.3 and Technical Appendix C for Shoreline Exposure and Climate Change Technical Appendix F.

The shoreline erosion metric is utilized to describe the potential for the methylation process to occur due to sediments exposed during water fluctuations and rewetting of soils.

"The degree to which water level fluctuations affect Hg methylation at a particular location is expected to vary depending on a host of site-specific conditions such as: the quantity and quality of organic carbon, the microbial community structure and abundance, whether sulfate or other electron acceptors become limited during the year, and the nature of inorganic Hg speciation and associations with solid phase sediment" (Eckley et al. 2017).

It is acknowledged that anoxic conditions are also a factor in the methylation of mercury due to the role of sulfate-reducing bacteria and nutrient loading (Chen et al. 2009; Dent et al. 2014). At this time the USACE does not have the capability to simulate dissolved oxygen in the available models.

#### *3.5.2.1.6 Water Temperature Effects Criteria Methodology*

Simulated water temperatures were evaluated and compared relative to NAA using the following metrics based on the 3-year average of 2011, 2015, and 2016 (the calendar years available from CE-QUAL-W2 modeling):

- **Summer Extremes:** Number of days in which the 7dADM water temperature is below 18° C or 64.4 °F. The 18° C thresholds corresponds to the Oregon State biologically based numeric Water Quality Temperature Standard for salmon and trout rearing and migration (OAR 340-041-0028) and represents "Optimal" conditions for juveniles and adult Chinook salmon in Koch, et.al., (2020). See Appendix D **Error! Reference source not found.** for values at each location, year, and alternative in the Water Quality Technical Appendix D for model formulas and results.
- **Days Near Temperature Target:** Number of days in which the 7dADM water temperature was within 2 F of the temperature target in two-time frames: April-August and September-March (see Technical Appendix D). Temperature targets used in this analysis are those applied in the CE-QUAL-W2 model (discussed in Appendix D Section 1.2.2) except for the Cougar (CGRO) target, where the temperature target defined in the Oregon State Total Maximum Daily Load (TMDL) was used. The Oregon TMDL temperature target for Cougar is cooler than that which was used in the CE-QUAL-W2 model and allowed for a more appropriate baseline for comparing the wide range of temperatures throughout the Alternatives. This allowed a comparison of alternatives at Cougar that did not inappropriately penalize the relatively cool temperatures (downstream of the dam) that resulted during deep drafting of Cougar Reservoir in some alternatives and better aligns with the needs of ESA-listed cold water fish species being considered in this PEIS. See Figure 1-361 for annual values at each location, year, and alternative in the Water Quality Technical Appendix D for model data formulas and results.

Water temperature effects were assigned based on the metrics above at each location and alternative using criteria in Table 3.5-7. Effects Criteria Thresholds at each location are summarized in Figure 3.5-56. Please refer to Technical Appendix D for description of these metrics. Thresholds were established based on the distribution of the data and expert opinion. The results from each alternative were summarized by each metric and then categorized based on tangible timeframes that are easily relatable (ex: increments of 5, 10 days) to Effects.

**Table 3.5-7. Water Temperature Effects Criteria Definitions**

| Effects Criteria Thresholds | Days Below 18 deg C (64.4 F) | Days Within 2 Deg F of Temperature Target (April-August) | Days Within 2 Deg F of Temperature Target (September - March) |
|---|---|---|---|
| Major Benefit | 15 | 50 | 50 |
| Moderate Benefit | 10 | 20 | 20 |
| Minor Benefit | 5 | 10 | 10 |
| Negligible | 0 | 0 | 0 |
| Minor Adverse | -5 | -10 | -10 |
| Moderate Adverse | -10 | -20 | -20 |
| Major Adverse | -15 | -50 | -50 |

**Days Below 18C (Summer)**

| Location | Alt1 | Alt2a | Alt2b | Alt3a | Alt3b | Alt4 |
|---|---|---|---|---|---|---|
| HCRO | Minor Adv | Moderate Adv | Major Adv | Major Adv | Major Adv | Major Adv |
| DEXO | Moderate Adv | Negligible | Negligible | Major Adv | Minor Adv | Major Adv |
| CGRO | Negligible | Negligible | Negligible | Negligible | Negligible | Negligible |
| SSFO | Major Adv | Negligible | Negligible | Negligible | Major Adv | Major Ben |
| BCLO | Negligible | Negligible | Negligible | Major Adv | Negligible | Negligible |
| ALBO | Minor Adv | Negligible | Negligible | Minor Adv | Negligible | Negligible |
| SLMO | Minor Adv | Negligible | Negligible | Minor Adv | Negligible | Minor Adv |

**Days Near Target (April - August)**

| Location | Alt1 | Alt2a | Alt2b | Alt3a | Alt3b | Alt4 |
|---|---|---|---|---|---|---|
| HCRO | Negligible | Negligible | Negligible | Major Ben | Moderate Ben | Major Ben |
| DEXO | Minor Ben | Negligible | Negligible | Negligible | Moderate Ben | Negligible |
| CGRO | Negligible | Negligible | Minor Ben | Negligible | Minor Ben | Negligible |
| SSFO | Moderate Ben | Moderate Ben | Moderate Ben | Moderate Ben | Moderate Ben | Minor Ben |
| BCLO | Moderate Ben | Moderate Ben | Moderate Ben | Moderate Adv | Negligible | Moderate Ben |

**Effects Criteria**

| Effects Criteria |
|---|
| Major Adv |
| Moderate Adv |
| Minor Adv |
| Negligible |
| Minor Ben |
| Moderate Ben |
| Major Ben |

**Days Near Target (September - March)**

| Location | Alt1 | Alt2a | Alt2b | Alt3a | Alt3b | Alt4 |
|---|---|---|---|---|---|---|
| HCRO | Negligible | Negligible | Negligible | Minor Ben | Negligible | Moderate Ben |
| DEXO | Negligible | Negligible | Negligible | Negligible | Negligible | Negligible |
| CGRO | Negligible | Negligible | Minor Ben | Minor Adv | Minor Ben | Negligible |
| SSFO | Negligible | Minor Ben | Minor Ben | Minor Ben | Negligible | Negligible |
| BCLO | Major Ben | Major Ben | Major Ben | Minor Ben | Negligible | Major Ben |

**Figure 3.5-56. Water Temperature Effects Criteria based on Number of Days below 18$^{o}$C (64.4$^{o}$F) (Top Table), Difference from NAA in Number of Days within 2$^{o}$F of Temperature Targets April-August (Middle Table) and September-March (Bottom Table).**

### *3.5.2.1.7 Total Dissolved Gas (TDG) Effects Criteria Methodology*

Dam releases from non-turbine outlets (defined as “spill” in this PEIS) are known to produce elevated TDG. The average number of days with spill per year are compared in each Alternative and dam (Table 3.5-8) and help to explain locations and alternatives with relatively higher TDG. Generally, TDG is generated initially at the high-head dam when spill occurs (e.g., Detroit Dam) and can increase downstream if spill occurs at the downstream re-regulating dam (e.g., Big Cliff Dam). TDG estimates from SYSTDG were then tabulated as the average number of days exceeding 110% TDG per year (Figure 3.5-57). The categorical TDG effects at each location and alternative relative to the NAA were developed based on the annual difference in number of days above 110% TDG compared to the NAA (Table 3.5-8, Figure 3.5-57). These categorical thresholds were chosen to represent the distribution of the summary data shown in Figure 3.5-57. The results from each alternative were summarized by each metric and then categorized based on tangible time frames that are easily relatable (ex: increments of 25, 50, 100 days). Effects are determined at the stream gage locations immediately downstream of the dams. Please refer to Technical Appendix D for model results.

**Table 3.5-8. Categorical TDG Effects Criteria Minimum Values**

| WVS PEIS Total Dissolved Gas Effects Criteria Minimum Values | |
|---|---|
| | **Annual Average** |
| **Effects Criteria Thresholds** | **Difference, in number of days, where TDG exceeds 110% compared to NAA** |
| Major Benefit | -100 |
| Moderate Benefit | -50 |
| Minor Benefit | -25 |
| Negligible | 0 |
| Minor Adverse | +25 |
| Moderate Adverse | +50 |
| Major Adverse | +100 |

| Location | Alt1 | Alt2a | Alt2b | Alt3a | Alt3b | Alt4 | Alt5 |
|---|---|---|---|---|---|---|---|
| DET | Moderate Ben | Moderate Ben | Moderate Ben | Major Adv | Moderate Adv | Moderate Ben | Moderate Ben |
| BCL | Major Ben | Moderate Ben | Moderate Ben | Major Adv | Moderate Adv | Major Ben | Major Ben |
| GPR | Negligible | Major Adv | Major Adv | Major Adv | Minor Adv | Major Adv | Moderate Adv |
| FOS | Negligible | Moderate Adv | Moderate Adv | Moderate Adv | Minor Adv | Negligible | Negligible |
| CGR | Minor Ben | Negligible | Minor Ben | Negligible | Minor Ben | Minor Ben | Minor Ben |
| HCR | Negligible | Negligible | Negligible | Negligible | Negligible | Negligible | Negligible |
| LOP | Negligible | Negligible | Negligible | Negligible | Negligible | Negligible | Negligible |
| DEX | Negligible | Negligible | Negligible | Minor Adv | Minor Adv | Negligible | Negligible |

| Effects Criteria |
|---|
| Major Adv |
| Moderate Adv |
| Minor Adv |
| Negligible |
| Minor Ben |
| Moderate Ben |
| Major Ben |

**Figure 3.5-57. TDG Effects Criteria based on Annual Number of Days above 110% TDG levels compared to the No Action Alternative and each Alternative downstream of the dams**

<u>**Construction**</u>

The PEIS will discuss general, qualitative effects from construction at the programmatic level. Site-specific project details for each construction measure will be determined during the implementation phase. Subsequent tiered NEPA documents would discuss detailed site-specific effects during the implementation phase.

Direct effects from the construction of water temperature control towers at Detroit, Lookout Point, Green Peter, Hills Creek and long drawdown at Cougar to construct the outlet works for the routine use of the diversion tunnel may limit temperature management, increase turbidity levels and effect TDG levels. Indirect effects are uncertain at this time.

### *3.5.2.2 No Action Alternative*

Water quality effects under the No Action Alternative (NAA) would be expected to continue as described in the Section 3.5 Water Quality Affected Environment. The monthly mean water temperature at each major stream gage location immediately below the dams (excluding the

Coast Fork and Long Tom tributaries) in NAA are shown in Appendix D Figure. Table 3.5-9 summarizes the effects of the NAA.Table 3.5-10 Summarizes the effects of the No Action alternative

**Table 3.5-9. Summary of Effects of the No Action Alternative**

| Subbasin | NAA |
|---|---|
| North Santiam | Detroit interim temperature operations would continue June 1 to August 30 and through the Regulating Outlets from October 1st to November 15. Effects would remain the same as they have existed since the issuance of the 2008 BiOp and implementation of operational water temperature management. TDG average number of days above 110% TDG would continue to occur on a frequent basis with TDG exceedances downstream of Big Cliff of up to 148 days and below Detroit Dam of up to 115 days. The Average Number of Days of Spill per Year would continue to be 127 days at Detroit and 84 days at Big Cliff. |
| South Santiam | Green Peter and Foster Reservoir temperature operations would remain the same whereby the Foster fish weir and night-time spill operations of 300 cfs would remain in effect from June 16 until August 15. Green Peter water temperatures would continue to meet state monthly targets in the spring and briefly in the fall, summer temperatures would be cooler than the monthly targets. Foster reservoir historic water temperature range would continue to meet the state monthly targets in the spring and fall, summer temperatures would continue to trend slightly cooler. Although no TDG measurements exist immediately downstream of Green Peter, it is estimated that the 110% TDG level would be exceeded on average for 12 days per year based on the amount of spill occurring in NAA. Foster would be above 110% TDG for 32 days on average. The Average Number of Days of Spill per year at Green Peter would continue to be 47 days and 209 days at Foster. |
| McKenzie | The Cougar water temperature control tower would continue to be operated annually to draft water to 1541 ft elevation by November 15. Under the No Action Alternative there would be no water temperature control operations at Blue River. Cougar Reservoir typically meets the state temperature targets utilizing the water temperature control tower as compared to pre-temperature control tower results. Blue River reservoir outflow water temperatures are closest to the state temperature targets from February through May and warmer from August through November when comparing the historic temperature range. |
| Middle Fork Willamette | Fall Creek would continue with informal temperature control operations by utilizing the fish horns for temperature management from month to month to release warmer water temperatures. Hills |

| Subbasin | NAA |
|---|---|
| | Creek reservoir temperatures have not exceeded 65 °F in the summer. Temperatures at Hills Creek have met most of the temperature targets from 2016 to 2020 but were lower than the TMDL targets from 2011 to 2015. The outflow temperatures are generally close to the temperature TMDL targets for Lookout Point/Dexter, except from October through November when temperatures are higher. At Fall Creek Reservoir the outflow temperatures are generally closest to the RA Targets and Temperature TMDL targets from February through May. Hills Creek would continue above 110% TDG level for an average of 19 days per year. Lookout Point is estimated that the 110% TDG level would be exceeded on average for 0 days per year based on the amount of spill occurring in NAA. TDG immediately below Dexter would continue above 110% for an average of 20 days per year. The Average Number of Days of Spill per year would continue at Hills Creek with 120 days, Lookout Point would continue to be 31 days and Dexter would continue to be 87 days. |
| Coast Fork Willamette & Long Tom | Temperature management operations are currently not implemented in the Coast Fork & Long Tom sub-basins and Cottage Grove, Dorena and Fern Ridge dams. Within the No Action Alternative there would be no change in water temperatures. There would be no change in effects as operations would remain the same. As there are no TDG gages downstream of Cottage Grove, Dorena, or Fern Ridge dams and no proposed measures, the effects would be similar to the Water Quality Affected Environment. |
| Mainstem Willamette | There are no WVS projects located on the Mainstem Willamette River, however water temperatures downstream of the WVS projects can assist in temperature regulation on the Willamette River. Water temperature modeling of tracking heat sources in the Willamette has shown the heat content in the Willamette at Salem/Keizer during May-August in 2011, 2015, and 2016 was typically less than 20% sourced from upstream dam releases, despite the fact that roughly 50 percent streamflow during those months is attributed to upstream dam releases. The Mainstem Willamette River at Salem (SLMO) and Mainstem Willamette River at Albany (ALBO) typically observes warmest temperatures in July and August. Coolest temperatures are observed in April and October for these two locations. To the USACE knowledge, there are no TDG gages located on the Willamette River and TDG is presume not to be an issue, as this is a water quality parameter most affected by dam operations. Therefore, TDG gages are typically located downstream of WVS projects where there are known issues. |

#### *3.5.2.2.1 North Santiam Dams*

**Water Temperature**

The North Santiam sub-basin represented at BCLO in Appendix D includes Detroit reservoir interim temperature operations, which assume up to 60% of total outflow released through the Spillway from June 1 to August 30 (if/when the lake is above the spillway crest) and up to 60% of total outflow released through the Regulating Outlets from October 1st to November 15. The low water year of 2015 resulted in Detroit Lake not filling to the spillway crest, which resulted in relatively warmer temperatures compared to 2011 and 2016, especially in July-October. Effects would remain the same as they have existed since the issuance of the BiOp and implementation of operational water temperature management. Please refer to section 3.5 Water Quality Affected Environment.

**TDG**

With current operations the same as stated in the Section 3.5.1 Water Quality Affected Environment, the average number of days above 110% TDG would continue to occur on a frequent basis with TDG exceedances downstream of Big Cliff of up to 148 days and below Detroit Dam of up to 115 days (Table 3.5-9). The Average Number of Days of Spill per Year would continue to be 127 days at Detroit and 84 days at Big Cliff (Table 3.5-9). TDG exceedance tend to occur when water is released through the non-turbine outlets of dams, spill and maintenance operations. Please refer to the Water Quality Technical Appendix D for further data formulas and results, such as boxplot figures of TDG by Alternative compared to the NAA.

**Turbidity**

Turbidity is typically low in the North Santiam; however recent wildfires may alter turbidity levels. Turbidity monitoring would be conducted as needed and not year-round. River Mechanics and Geomorphology Chapter 3.3 for NAA results of Potential for changes in sediment supply states “a portion of the incoming sediment load will continue to pass run-of-river reservoirs and free-flowing reaches at magnitudes and rates similar to those historically experienced”.

**HABs**

In Section 3.3 River Mechanics & Geomorphology sections for Head-of-Reservoir, Shoreline Exposure, Sediment Re-Entrainment or Bank Failure Potential and Climate Change Technical Appendix F. Increased nutrient inputs may facilitate an increase in algae blooms. At this time the USACE cannot control cyanobacteria bloom formation and growth. Further research is needed to determine factors that assist in toxin production and toxin suppression.

**Mercury**

In River Mechanics and Geomorphology Chapter 3.3 for NAA results of Shoreline Exposure and Climate Change Technical Appendix F. River Mechanics and Geomorphology Chapter 3.3 for

NAA results of Shoreline Exposure states “the amount of time that the storage project WSEs spend at any given elevation will not change from historical conditions. Negligible change in the amount of time that the storage project WSEs spend at any given elevation indicating that reservoir shoreline erosion processes are expected to continue at locations and rates similar to those historically experienced at each project”. This metric is utilized to describe the potential for the methylation process to occur due to water fluctuations and rewetting of soils.

##### *3.5.2.2.2 South Santiam Dams*

**Water Temperature**

South Santiam sub-basin which includes Green Peter and Foster Reservoir temperature operations would remain the same whereby the Foster fish weir and night-time spill operations of 300 cfs would remain in effect from June 16 until August 15. As Foster is a reregulating dam for Green Peter these temperature operations would remain under the No Action Alternative. As compared to the state temperature targets and historic temperature range Green Peter water temperatures would continue to meet these monthly targets in the spring and briefly in the fall, summer temperatures would be cooler than the monthly targets (Fig 3.4-3; Table 3.4-1). Foster reservoir historic water temperature range would continue to meet the state monthly targets in the spring and fall, summer temperatures would continue to trend slightly cooler (Figure 3.4-6; Table 3.4-1).

**TDG**

Under the No Action Alternative operations would remain as described in the Section 3.5 Water Quality Affected Environment. Although no TDG measurements exist immediately downstream of Green Peter, it is estimated that the 110% TDG level would be exceeded on average for12 days per year based on the amount of spill occurring in NAA. Foster would be above 110% TDG for 32 days on average (Table 3.5-9). The Average Number of Days of Spill per year at Green Peter would continue to be 47 days and 209 days at Foster (Table 3.5-9). TDG exceedance tend to occur when water is released through the non-turbine outlets of dams, spill and maintenance operations.

**Turbidity**

Turbidity monitoring would be conducted as needed and not year-round. Please refer to River Mechanics and Geomorphology Chapter 3.3 for NAA results of Potential for changes in sediment supply “a portion of the incoming sediment load will continue to pass run-of-river reservoirs and free-flowing reaches at magnitudes and rates similar to those historically experienced”.

**HABs**

In Section 3.3 River Mechanics & Geomorphology sections for Head-of-Reservoir, Shoreline Exposure, Sediment Re-Entrainment or Bank Failure Potential and Climate Change Technical

Appendix F. Increased nutrient inputs may facilitate an increase in algae blooms. At this time the USACE cannot control cyanobacteria bloom formation and growth. Further research is needed to determine factors that assist in toxin production and toxin suppression. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

Please refer to River Mechanics and Geomorphology Chapter 3.3 for NAA results of Shoreline Exposure states "the amount of time that the storage project WSEs spend at any given elevation will not change from historical conditions. Negligible change in the amount of time that the storage project WSEs spend at any given elevation indicating that reservoir shoreline erosion processes are expected to continue at locations and rates similar to those historically experienced at each project". This metric is utilized to describe the potential for the methylation process to occur due to water fluctuations and rewetting of soils.

*3.5.2.2.3 McKenzie Dams*

**Water Temperature**

McKenzie sub-basin includes Cougar and Blue River dams. The Cougar water temperature control tower would continue to be operated annually to draft water to 1541 ft elevation by November 15. Once water elevation is below 1541 ft there are no temperature control operations. Under the No Action Alternative there would be no water temperature control operations at Blue River. There would be no change in effects as operations would remain the same. As described in Section 3.5 Water Quality Affected Environment Cougar Reservoir typically meet the state temperature targets utilizing the water temperature control tower as compared to pre-temperature control tower results (Figure 3.5-3; Table 3.5-1). Blue River reservoir outflow water temperatures are closest to the state temperature targets from February through May and warmer from August through November when comparing the historic temperature range (Figure 3.5-6; Table 3.5-1).

**TDG**

Cougar reservoir would remain as described in the Section 3.5 Water Quality Affected Environment with 57 average days above 110% TDG levels (Table 3.5-9). The Average Number of Days of Spill per year at Cougar would continue to be 162 days (Table 3.5-9). In Hydrologic Processes states Cougar outflows would "meet downstream flow targets in all years" under the NAA. TDG exceedance may occur if water is released through the non-turbine outlets of dams, spill and maintenance operations.

**Turbidity**

Under the NAA at Cougar reservoir, turbidity monitoring would be conducted as needed and not year-round. Please refer to River Mechanics and Geomorphology Chapter 3.3 for NAA results of Potential for changes in sediment supply “a portion of the incoming sediment load will continue to pass run-of-river reservoirs and free-flowing reaches at magnitudes and rates similar to those historically experienced”.

**HABs**

Please refer to the Section 3.5 Water Quality Affected Environment and Section 3.3 River Mechanics & Geomorphology sections for Head-of-Reservoir, Shoreline Exposure, Sediment Re-Entrainment or Bank Failure Potential and Climate Change Technical Appendix F. Increased nutrient inputs may facilitate an increase in algae blooms. At this time the USACE cannot control cyanobacteria bloom formation and growth. Further research is needed to determine factors that assist in toxin production and toxin suppression. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

Please refer to the Section 3.5 Water Quality Affected Environment and River Mechanics and Geomorphology Chapter 3.3 for NAA results of Shoreline Exposure and Climate Change Technical Appendix F. River Mechanics and Geomorphology Chapter 3.3 for NAA results of Shoreline Exposure states “the amount of time that the storage project WSEs spend at any given elevation will not change from historical conditions. Negligible change in the amount of time that the storage project WSEs spend at any given elevation indicating that reservoir shoreline erosion processes are expected to continue at locations and rates similar to those historically experienced at each project”. This metric is utilized to describe the potential for the methylation process to occur due to water fluctuations and rewetting of soils.

*3.5.2.2.4 Middle Fork Willamette Dams*

**Water Temperature**

Middle Fork Willamette includes Hills Creek, Lookout Point, Dexter, and Fall Creek dams. Fall Creek would continue with informal temperature control operations by utilizing the fish horns for temperature management from month to month to release warmer water temperatures. The nine fish horns are located at varying elevations (3-720 ft, 3-765 ft, 3-800 ft) and can provide water to the Adult Fish Facility (AFF). As described in Section 3.5 Water Quality Affected Environment, Hills Creek reservoir temperatures have not exceeded 65 °F in the summer (Figure 3.5-25). Temperatures at Hills Creek met most of the temperature targets from 2016 to 2020 but were lower than the TMDL targets from 2011 to 2015 (Figure 3.5-26; Figure 3.5-27). The outflow temperatures are generally close to the temperature TMDL targets for Lookout Point/Dexter, except from October through November when temperatures are higher (Figure 3.5-29; Figure 3.5-30). At Fall Creek Reservoir the outflow temperatures are generally closest to the RA Targets and Temperature TMDL targets from February through May (Figure 3.5-30 through 33).

**TDG**

Hills Creek would continue above 110% TDG level for an average of 19 days per year. Although no TDG measurements exist immediately downstream of Lookout Point, it is estimated that the 110% TDG level would be exceeded on average for 0 days per year based on the amount of spill occurring in NAA. TDG immediately below Dexter would continue above 110% for an average of 20 days per year (Table 3.5-9). The Average Number of Days of Spill per year would continue at Hills Creek with 120 days, Lookout Point would continue to be 31 days and Dexter would continue to be 87 days (Table 3.5-9). In Table 3.2-4 Hydrologic Processes states Hills Creek outflows would “meet downstream flow targets. Minimum flow is 400 cfs. Lookout Point/Dexter would miss downstream flow target in October of driest years” under the NAA. TDG exceedance may occur if water is released through the non-turbine outlets of dams, spill and maintenance operations.

**Turbidity**

Please refer to Section 3.5 Water Quality Affected Environment. Turbidity monitoring would be conducted as needed and not year-round. River Mechanics and Geomorphology Chapter 3.3 for NAA results of potential for changes in sediment supply states “a portion of the incoming sediment load will continue to pass run-of-river reservoirs and free-flowing reaches at magnitudes and rates similar to those historically experienced”.

**HABs**

Please refer to the Section 3.5 Water Quality Affected Environment and River Mechanics & Geomorphology Section 3.3 for Head-of-Reservoir, Shoreline Exposure, Sediment Re-Entrainment or Bank Failure Potential and Climate Change Technical Appendix F. Increased nutrient inputs may facilitate an increase in algae blooms. At this time the USACE cannot control cyanobacteria bloom formation and growth. Further research is needed to determine factors that assist in toxin production and toxin suppression. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

Please refer to the Section 3.5 Water Quality Affected Environment and River Mechanics and Geomorphology Chapter 3.3 for NAA results of Shoreline Exposure and Climate Change Technical Appendix F. River Mechanics and Geomorphology Chapter 3.3 for NAA results of Shoreline Exposure states “the amount of time that the storage project WSEs spend at any given elevation will not change from historical conditions. Negligible change in the amount of time that the storage project WSEs spend at any given elevation indicating that reservoir shoreline erosion processes are expected to continue at locations and rates similar to those historically experienced at each project”. This metric is utilized to describe the potential for the methylation process to occur due to water fluctuations and rewetting of soils.

#### *3.5.2.2.5 Coast Fork Dams and Long Tom*

**Water Temperature**

Temperature management operations are currently not implemented in the Coast Fork & Long Tom sub-basins and Cottage Grove, Dorena and Fern Ridge dams. Within the No Action Alternative there would be no change in water temperatures. There would be no change in effects as operations would remain the same. As described in Section 3.5 Water Quality Affected Environment there are Total Maximum Daily Load (TMDL) targets but no 7dADM state temperature targets for the Coast Fork sub-basins. Historically, Cottage Grove outflow temperatures are warmest in August and begin to cool in late-September (Figure 3.7-2). Dorena Reservoir outflow temperatures are historically warmest in late- August and begin to cool by early October (Figure 3.7-5). Fern Ridge outflow temperatures are typically warmest in August and begin to cool in September (Figure 3.7-8).

**TDG**

As there are no TDG gages downstream of Cottage Grove, Dorena, or Fern Ridge dams and no proposed measures, the effects would be similar to the Water Quality Affected Environment. In Table 3.2-5 Hydrologic Processes states Dorena outflows would "maintain minimum flows except in November of driest years. Cottage Grove outflows would maintain minimum flows except in November of driest years" under the NAA. TDG exceedance may occur if water is released through the non-turbine outlets of dams, spill and maintenance operations.

**Turbidity**

Please refer to Section 3.5 Water Quality Affected Environment. Turbidity monitoring would be conducted as needed and not year-round. River Mechanics and Geomorphology Chapter 3.3 for NAA results of Potential for changes in sediment supply states "a portion of the incoming sediment load will continue to pass run-of-river reservoirs and free-flowing reaches at magnitudes and rates similar to those historically experienced".

**HABs**

Please refer to the Section 3.5 Water Quality Affected Environment. River Mechanics & Geomorphology Section 3.3 sections for Head-of-Reservoir, Shoreline Exposure, Sediment Re-Entrainment or Bank Failure Potential and Climate Change Technical Appendix F. Increased nutrient inputs may facilitate an increase in algae blooms. At this time the USACE cannot control cyanobacteria bloom formation and growth. Further research is needed to determine factors that assist in toxin production and toxin suppression. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

Please refer to the Section 3.5 Water Quality Affected Environment and River Mechanics and Geomorphology Chapter 3.3 for NAA results of Shoreline Exposure and Climate Change Technical Appendix F. River Mechanics and Geomorphology Chapter 3.3 for NAA results of Shoreline Exposure states "the amount of time that the storage project WSEs spend at any given elevation will not change from historical conditions. Negligible change in the amount of time that the storage project WSEs spend at any given elevation indicating that reservoir shoreline erosion processes are expected to continue at locations and rates similar to those historically experienced at each project". This metric is utilized to describe the potential for the methylation process to occur due to water fluctuations and rewetting of soils.

*3.5.2.2.6 Mainstem Willamette River*

**Water Temperature**

There are no WVS projects located on the Mainstem Willamette River, however water temperatures downstream of the WVS projects can assist in temperature regulation on the Willamette River. Water temperature modeling of tracking heat sources in the Willamette has shown the heat content in the Willamette at Salem/Keizer during May-August in 2011, 2015, and 2016 was typically less than 20% sourced from upstream dam releases, despite the fact that roughly 50 percent streamflow during those months is attributed to upstream dam releases (Rounds and Stratton-Garvin, In Press). The Mainstem Willamette River at Salem (SLMO) and Mainstem Willamette River at Albany (ALBO) typically observes warmest temperatures in July and August in Appendix D. Coolest temperatures are observed in April and October for these two locations.

**TDG**

To the USACE knowledge, there are no TDG gages located on the Willamette River and TDG is presume not to be an issue, as this is a water quality parameter most affected by dam operations. Therefore, TDG gages are typically located downstream of WVS projects where there are known issues.

**Turbidity**

Turbidity monitoring would be conducted as needed and not year-round. Please refer to River Mechanics and Geomorphology Chapter 3.3 for NAA results of Potential for changes in sediment supply "a portion of the incoming sediment load will continue to pass run-of-river reservoirs and free-flowing reaches at magnitudes and rates similar to those historically experienced".

**HABs**

To the USACE knowledge, there have been no OHA advisories near Albany and Salem. Please refer to the No Action Alternative sections within River Mechanics & Geomorphology Section

3.3 sections for Head-of-Reservoir, Shoreline Exposure, Sediment Re-Entrainment or Bank Failure Potential and Climate Change Technical Appendix F. Increased nutrient inputs may facilitate an increase in algae blooms. At this time the USACE cannot control cyanobacteria bloom formation and growth. Further research is needed to determine factors that assist in toxin production and toxin suppression. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

##### *3.5.2.2.7 Climate Change*

Please reference Technical Appendices B and F for Climate Change qualitative effects. Water Quality parameters such as Water Temperature and TDG would be influenced by refill timing, storage volume, and outflow at each dam. Climate change projections for the 2030s and 2070s under RCP 8.5 show higher project inflow December-March and lower inflow April-November for the Willamette Basin. Higher winter flow may increase TDG levels if no TDG management is in place, as turbine capacity at power projects would likely be exceeded more often and result in “spill” releases through non-power outlets. Higher winter flows occurring in December-January would not be stored, as the guide curves for Willamette Projects generally begin February 1. Therefore, climate change will likely lead to a decreased release volumes in spring and summer compared to the Affected Environment. Decreased storage will likely decrease the ability to manage dam releases from different outlets for temperature management, leading to less normative release temperatures (cooler in spring-early summer; warmer in autumn).

In the No Action Alternative, Detroit dam, Green Peter dam, Foster dam, Cougar dam, Hills Creek dam, Lookout Point dam, and the Mainstem Willamette river would potentially have less flow during the summer which may cause and increase downstream water temperatures. Parameters such as Turbidity, HABs and Mercury may be influenced by reservoir storage and time of year. For example, reduced reservoir storage in the summer may facilitate an increase in algae blooms due to warm water temperatures as observed in Detroit, Green Peter, Foster, Blue River, Cougar, Hills Creek, Lookout Point, and Fall Creek reservoirs (Technical Appendix B Hydrology and Hydraulics).

#### ***3.5.2.3 Alternative 1 – Project Storage Alternative***

This section describes the Alternative 1 effects to water quality. All effects determinations are in comparison to the NAA unless stated otherwise.

##### *3.5.2.3.1 North Santiam Dams*

**<u>Water Temperature</u>**

North Santiam sub-basin would include a Water Temperature Control tower at Detroit dam for water temperature management. Big Cliff/ Detroit Dams would have a Negligible effect of days below 18C (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Major Benefit for Days Near Temperature Target from September through March

(Figure 3.5-56; Figure 3.5-14). Please refer to Technical Appendix D for all temperature model results.

Alternative 1 as compared to the NAA (Appendix D Figure 1-384) downstream of Detroit and Big Cliff dams (BCLO) would in the 2011-year scenario see water temperature increase up to 4 degrees starting in June through October. In the 2015-year scenario water temperatures would increase 2 to 3 degrees from May to August and then decrease of 4 to 7 degrees in September to October. In the 2016-year scenario water temperatures would increase 2 to 12 degrees from May to September and then decrease by 2 degrees in October. For the Average of the three years water temperatures would increase 1 to 6 degrees from May to September and then decrease by 2 degrees in October. [18]

**TDG**

Both Detroit and Big Cliff dams would have a Beneficial effect when including the structural improvements for TDG management under Alternative 1 as compared to the NAA. Detroit would have a Moderate Benefit (Figure 3.5-57; Table 3.5-12).

Under Alternative 1, the average number of days above 110% TDG levels at Big Cliff is 31 and Detroit is 39. This equates to a reduction in TDG below Big Cliff of 117 annually. Annual differences in number of days above 110% of TDG exceedances and below Detroit is reduced to 77 days as compared to the NAA. The Average Number of Days of Spill per year at Detroit is 62 days and Big Cliff is 88 days.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events relative to the NAA. Please refer to River Mechanics and Geomorphology section 3.3.2.3 there is a Moderate change downstream of Detroit Dam in relation to potential for changes in sediment supply with fine grained sediment passing into Big Cliff run-of reservoir. These additional fine-grained sediments that enter Big Cliff Reservoir from Detroit Reservoir may partially settle.

**HABs**

The River Mechanics and Geomorphology Section 3.3.2.3 concludes that Deeper drawdowns typically occur during lower flow periods, such that Alternative 1 has Negligible change as compared to the NAA in the potential for head-of-reservoir sediment mobilization at all WVS storage projects. The shoreline exposure relative to the NAA metrics relative to the NAA result in a Major change for Detroit reservoir. Big Cliff reservoir is a run-of river project that operates in a small range of pool elevations and is not included in this metric. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

[18] For further explanation on how the 3 representative water years for temperature were selected Section 3.5.2.1 and Appendix D.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Detroit reservoir. Big Cliff reservoir is a run-of river project that operates in a small range of pool elevations and is not included for this metric. Please refer River Mechanics and Geomorphology Section 3.3.2.3 for the qualitative analysis of Alternative 1 as compared to the NAA. Alternative 1 would have a Major change in shorelines exposure relative to the NAA at Detroit dam. As there is Major change in shoreline exposure at Detroit dam there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect. Currently the amount or levels of mercury in Detroit reservoir is unknown.

*3.5.2.3.2 South Santiam Dams*

**Water Temperature**

Alternative 1 includes a Water Temperature Control tower at Green Peter Reservoir and a modification to the existing outlets at Foster Reservoir to allow for a Facility Warm Water Supply (FWWS) pipe and modified fish weir. Green Peter/Foster Dams would see a Major Adverse effect for Days below 18 C (64.4 F) (64.4 F) (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March (Figure 3.5-56; Figure 3.5-14).

Results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the South Santiam River near Foster gaging site (SSFO; Appendix D Figure 1-385) in the 2011-year scenario would see an increase starting in May through October up to 10 degrees. Water temperatures are unnaturally cold during the summer below Green Peter Dam (under the NAA), so large changes in outflow temperatures is to be expected if a Water Temperature Control tower were to be constructed. In the 2015-year scenario an increase of 1 to 5 degrees from April to July and then decrease from 2 to 4 degrees from August to October. In the 2016-year scenario an increase up to 10 degrees from April to September and then decrease by 1 degree in October. For the Average of the three years (2011, 2015, 2016) an increase 1 to 6 degrees from April through September and then decrease by 2 degrees in October.

**TDG**

Under Alternative 1, structural improvement measures for TDG management would have a Negligible effect at both Green Peter and Foster (Figure 3.5-57; Table 3.5-12).

Under Alternative 1, Green Peter reservoir results in 13 average number of days above 110% TDG levels, whereas Foster would be 20 average number of days above 110%. Green Peter has a reduction of 0 days of TDG exceedances and Foster is reduced by 12 days as compared to the No Action Alternative. The Average Number of Days of Spill per year at Green Peter is 48 days and Foster is 285 days .

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. The River Mechanics and Geomorphology Section 3.3.2.3 concludes there is potential for a Moderate change in sediment supply with additional fine-grained sediments passing into Foster which may partially settle as compared to the NAA. Increased fine-grained sediment supply is due deeper drafts in Green Peter Reservoir that have the potential to pass sediment through Green Peter Dam and partially through the Foster reservoir.

**HABs**

There are no measures for HABs within Green Peter and Foster. The River Mechanics and Geomorphology Section 3.3.2.3 concludes that deeper drawdowns typically occur during lower flow periods, such that Alternative 1 has Negligible change from the NAA in the potential for head-of-reservoir sediment mobilization at all WVS storage projects. Alternative 1 would have a Major change for shoreline exposure at Green Peter reservoir and Negligible for Foster reservoir relative to the NAA. Sediment Re-Entrainment and Bank Failure Potential metric would have a Major change for Green Peter reservoir and Negligible for Foster reservoir. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Green Peter and Foster. Please refer River Mechanics and Geomorphology Section 3.3.2.3 for the qualitative analysis of Alternative 1 as compared to the NAA. Alternative 1 would have a Major change in shoreline exposure relative to the NAA at Green Peter reservoir and Negligible for Foster reservoir. As there is Major change in shoreline exposure at Green Peter dam there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.3.3 McKenzie Dams*

**Water Temperature**

There are no Water Temperature measures for Cougar or Blue River dams under Alternative 1 as there is already a Water Temperature Control Tower at Cougar. Blue River dam is low priority as Cougar dam provides water temperature control to the McKenzie river. Cougar Dam and would see a Negligible effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March (Figure 3.5-56; Figure 3.5-14).

Results are compared to the NAA the Monthly Mean of Daily Mean water temperatures (deg F) at the South Fork McKenzie River near Rainbow site (CGRO; Appendix D Figure 1-386) in the

2011-year scenario there would be no temperature difference as compared to the NAA. In the 2015-year scenario a decrease up to 2 degrees from July to October. In the 2016-year scenario a decrease is observed up to 1 degree in July and increase of 5 degrees in September is observed. For the Average of the three years (2011, 2015, 2016) a 1-degree temperature decrease observed in July and October, an increase of 1 degree is observed in September.

**TDG**

Cougar dam results in a Minor Benefit when including the structural improvement for TDG management measure under Alternative 1 compared to the NAA (Figure 3.5-57; Table 3.5-12).

Under Alternative 1, the average number of days above 110% TDG levels would be 16 at Cougar reservoir. Cougar reservoir has a reduction of 41 days of TDG exceedances as compared to the NAA . The Average Number of Days of Spill per year at Cougar is 160 days under Alternative 1. Blue River is expected to have similar operations as stated in the Affected Environment and NAA. As the RO's are routinely utilized and not turbines TDG levels would not be expected to change.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. In River Mechanics and Geomorphology Section 3.3.2.3 there is a Minor change in sediment supply with additional fine-grained sediments passing out of Cougar downstream into the McKenzie River as compared to the NAA. Increased fine-grained sediment supply is due to deeper drafts that may pass fine-grained sediment out of Cougar Reservoir. Blue River reservoir would have a potential for a Moderate change in fine-grained sediment supply. Increased fine-grained sediment supply is due to deeper drafts in Blue River.

**HABs**

The River Mechanics and Geomorphology Section 3.3.2.3 concludes that deeper drawdowns are typically occurring during lower flow periods, such that Alternative 1 relative to the NAA has Negligible effect in the potential for head-of-reservoir sediment mobilization and sediment trap efficiency at all WVS storage projects. Alternative 1 relative to the NAA would have a Major change for the Shoreline Exposure metric at Cougar and Blue River dams. Sediment Re-Entrainment and Bank Failure Potential metric would have a Moderate change for Cougar dam and Major change for Blue River. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Cougar and Blue River. Please refer River Mechanics and Geomorphology Section 3.3.2.3 for the qualitative analysis of Alternative 1 as compared to the NAA. Alternative 1 would have a Major change in shoreline exposure relative to the NAA at Cougar and Blue River dams. As there is Major change in shoreline exposure at Cougar and Blue River dams there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect. However, the current amount or levels of mercury in Cougar and Blue River is unknown.

#### *3.5.2.3.4 Middle Fork Willamette Dams*

**Water Temperature**

Alternative 1 includes a Water Temperature Control tower at Lookout Point to better regulate downstream temperatures to Dexter reservoir. Lookout Point/Dexter Dams would see a Moderate Adverse effect for Days below 18 C (64.4 F) (Summer), Minor Benefit for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March (Figure 3.5-56; Figure 3.5-14).

Results are also compared to the NAA the Monthly Mean of Daily Mean water temperatures (deg F) at the Middle Fork Willamette River near Dexter gaging site (DEXO; Appendix D Figure 1-388) in the 2011-year scenario would see an increase starting in May through September up to 6 degrees and decrease by 6 degrees in October. In the 2015-year scenario: increase up to 4 degrees from April to June and then decrease by 4 degrees from July to October. In the 2016-year scenario an increase up to 6 degrees from April to August and then decrease by 6 degrees in October. For the Average of the three years (2011, 2015, 2016): increase up to 3 degrees from April to August and then decrease by 5 degrees in October.

Although there are no measures for Hills Creek in Alternative 1, water temperature was modeled. Hills Creek Dam would see a Minor Adverse effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March (Figure 3.5-57; Figure 3.5-14).

As compared to the NAA the Monthly Mean of Daily Mean water temperatures (deg F) at the Middle Fork Willamette River above Salt Creek gaging site (HCRO; Appendix D Figure 1-387) in the 2011-year scenario there would be no temperature difference from April until September and decrease by 1 degree in October as compared to the NAA. In the 2015-year scenario a decrease by 3 degrees from April to June, increase by 3 degrees in July to September, decrease by 3 degrees in October. In the 2016-year scenario there would be no temperature change observed in April and then a decrease observed up to 5 degrees from May until October. For the Average of the three years (2011, 2015, 2016) a temperature decrease up to 2 degrees is observed in May, June, and October.

There are no water temperature measures for Fall Creek, as such water temperature was not simulated. Given the low impact that was expected there were no temperature modeling.

**TDG**

Hills Creek, Lookout Point, and Dexter dams have a Negligible effect when including the structural improvement for TDG management measure included in Alternative 1 compared to the NAA (Figure 3.5-57; Table 3.5-12). Although Hills Creek was not included for a structural measure the information is provided as to what TDG effects might be observed.

Under Alternative 1, the Average number of days above 110% TDG levels at Hills Creek is 9 average days, Lookout Point is 0, and Dexter is 5 average days. Hills Creek has a reduction of 9 days of TDG exceedances, Lookout Point has 0 days reduction, and Dexter is reduced by 15 days as compared to the No Action Alternative. The Average Number of Days of Spill per year at Hills Creek is 93 days, Lookout Point is 51 days and Dexter is 89 days. Fall Creek is expected to have similar operations as stated in the Affected Environment and NAA, as such there would not be expected TDG levels to change.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. The River Mechanics and Geomorphology Section 3.3.2.3 concludes that there is a Moderate change in sediment supply with additional fine-grained sediments passing out of Hills Creek into the Middle Fork Willamette above Lookout Point as compared to the NAA. Increased fine-grained sediment supply is due to deeper drafts that may pass fine-grained sediment out of Hills Creek Reservoir and deposit within Lookout Point reservoir. Dexter reservoir would have a potential for a Minor change in fine-grained sediment supply. Downstream of Dexter Dam there would be a Negligible potential for change in sediment supply relative to the NAA.

**HABs**

There are no measures for HABs within Hills Creek, Lookout point and Fall Creek. The River Mechanics and Geomorphology Section 3.3.2.3 concludes that deeper drawdowns are typically occurring during lower flow periods, such that Alternative 1 has Negligible change in the potential for head-of-reservoir sediment mobilization at all WVS storage projects as compared to the NAA. The Shoreline Exposure metric would have a Major change for Hills Creek and Lookout Point. Fall Creek reservoir would see a Negligible change. Dexter reservoir is a run-of river project that operates in a small range of pool elevations and is not included in this metric. Sediment Re-Entrainment and Bank Failure Potential metric would have a Major change for Hills Creek, Minor change for Lookout Point, and Negligible change for Fall Creek. Dexter reservoir is a run-of river project that operates in a small range of pool elevations and is not included in this metric. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Hills Creek, Lookout Point and Fall Creek. Please refer River Mechanics and Geomorphology Section 3.3.2.3 for the qualitative analysis of Alternative 1 as compared to the NAA. The Shoreline Exposure metric within Section 3.3 would have a Major change for Hills Creek and Lookout Point as compared to the NAA. Fall Creek reservoir would see a Negligible change. Dexter reservoir is a run-of river project that operates in a small range of pool elevations and is not included in this metric. Currently the amount or levels of mercury in Hills Creek, Lookout Point, and Fall Creek is unknown. As there would be a Major change in shoreline exposure at Hills Creek and Lookout Point dams relative to the NAA there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.3.5 Coast Fork Dams and Long Tom*

**Water Temperature**

There are no measures at Cottage Grove, Dorena and Fern Ridge dams under Alternative 1. Water temperatures would remain as described in the No Action Alternative and Affected Environment.

**TDG**

There are no TDG management measures at Cottage Grove, Dorena and Fern Ridge dams under Alternative 1. TDG would remain as described in the No Action Alternative and Affected Environment.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. The River Mechanics and Geomorphology Section 3.3.2.3 concludes that potential for changes in sediment supply would have a Moderate change as compared to the NAA in fine grained sediments into the dams due to deeper drafts from reduction of reservoir storage passing into the Coast Fork Willamette and Row River from Cottage Grove and Dorena dams. Increased fine-grained sediment supply is due deeper drafts in Cottage Grove and Dorena dams that have potential to induce bank erosion and sloughing. For Fern Ridge reservoir there is Negligible effect in sediment supply relative to the No Action Alternative in the Long Tom River free-flowing reach.

**HABs**

Please refer to the Section 3.5 Water Quality Affected Environment. The River Mechanics and Geomorphology Section 3.3.2.3 concludes that deeper drawdowns are typically occurring during lower flow periods, such that Alternative 1 has Negligible effect in the potential for head-of-reservoir sediment mobilization and sediment trap efficiency at all WVS storage projects. The Shoreline Exposure metric within Section 3.3 would have a Major change Cottage

Grove and Dorena reservoirs. Fern Ridge reservoir has a Negligible effect. Sediment Re-Entrainment and Bank Failure Potential metric would have a Moderate change for Cottage Grove and Dorena reservoirs. Fern Ridge reservoir has a Negligible effect. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Cottage Grove, Dorena, and Fern Ridge dams. The River Mechanics and Geomorphology Section 3.3.2.3 concludes that Alternative 1 would have a Major change in shoreline exposure relative to the NAA for Cottage Grove and Dorena Dams. Fern Ridge reservoir has a Negligible effect. Mercury has been studied in Cottage Grove and Dorena Dams as Total Mercury (inorganic) and Methylated Mercury (organic) in sediment (Ambers et al. 2001; Eckley et al. 2015; Eckley et al. 2017). As there would be a Major change in shoreline exposure at Cottage Grove and Dorena dams there is potential for an increase for the methylation process to occur with water fluctuations and rewetting of soils.

#### *3.5.2.3.6 Mainstem Willamette River*

**Water Temperature**

Alternative 1 water temperature results for the Mainstem Willamette River at Salem (SLMO) results in a Minor Adverse effect for Days below 18 C (64.4 F) (Summer). Results are not reported for “Days Near Temperature Target from April through August” or “Days Near Temperature Target from September through March” because there are no temperature targets (Figure 3.5-56; Figure 3.5-14).

Mainstem Willamette River results are compared to the NAA the Monthly Mean of Daily Mean water temperatures (deg F) at the Willamette River near Salem gaging site (SLMO; Appendix D, Figure 1-364) in the 2011-year scenario there would be no change in temperature in April and May; 1-degree temperature increase from June until September and then a 1 degree decrease in October. In the 2015-year scenario an increase up to 2-degree is observed from April until June and then decrease up to 3 degrees from July until September. In the 2016-year scenario a water temperature increase up to 2 degrees from April until August and then 1 degree decrease in October. For the Average of the three years (2011, 2015, 2016) a 2-degree temperature increase is observed in May and June and then a 1 degree decrease in October.

Alternative 1 water temperature results within the Mainstem Willamette River at Albany (ALBO) results in a Minor Adverse effect for Days below 18 C (64.4 F) (Summer). Results are not reported for “Days Near Temperature Target from April through August” or “Days Near Temperature Target from September through March” because there are no temperature targets (Figure 3.5-56; Figure 3.5-14).

Mainstem Willamette River results are compared to the NAA the Monthly Mean of Daily Mean water temperatures (deg F) at the Willamette River at Albany gaging site (ALBO; Appendix D,

Figure 1-364) in the 2011-year scenario a water temperature increase up to 1 degree is observed from July until September and then a 2 degree decrease in October. In the 2015-year scenario a water temperature increases up to 2 degree is observed in April and May and then 1 degree decrease in July and August. In the 2016-year scenario a water temperature increases up to 2-degree is observed from April until June and then a 1-degree temperature decrease in September and October. For the Average of the three years (2011, 2015, 2016) a water temperature increases up to 1-degree is observed from April until June and then 1-degree decrease in October.

**TDG**

To the USACE knowledge, there are no TDG gages located on the Willamette River and TDG is presume not to be an issue, as this is a water quality parameter most affected by dam operations. Therefore, TDG gages are typically located downstream of WVS projects where there are known issues.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.3 Potential for changes in sediment supply “there is Negligible potential for changes in sediment supply relative to the No Action Alternative in the Middle Willamette free-flowing reach”.

**HABs**

To the USACE knowledge, there are no OHA HAB advisories near Albany and Salem in public records. At this time the USACE cannot control cyanobacteria bloom formation and growth. Further research is needed to determine factors that assist in toxin production and toxin suppression.

*3.5.2.3.7 Climate Change*

Please reference Technical Appendices B and F for Climate Change qualitative effects. Compared to NAA, Alternative 1 would potentially have more resiliency against climate change effects on water temperature and TDG (increased water temperature control) below Detroit and Green Peter as a result of the proposed SWS and TDG abatement measures at each location. Parameters such as Turbidity and Mercury will likely experience similar effects as those described under NAA. Increased releases from the lake surface via the proposed SWS at Detroit, Green Peter, and Lookout Point combined with reduced summer flow volumes under Alternative 1 could lead to increased phytoplankton (algae) compared to NAA (Technical Appendix B Hydrology and Hydraulics).

*3.5.2.3.8 Summary of Effects*

Below is provided a summary of Alternative 1's overall water quality effects.

**Table 3.5-10. Summary of effects to Alternative 1 as compared to the NAA.**

| Subbasin | Alternative 1 |
|---|---|
| North Santiam | Big Cliff observes a negligible to beneficial effect for water temperatures with the inclusion of a Water Temperature Control tower at Detroit dam. A beneficial effect to TDG levels is observed with structural improvement included at Detroit and Big Cliff. |
| South Santiam | Foster observes adverse to beneficial effects to downstream water temperatures with the inclusion of a water temperature control tower at Green Peter. A negligible effect to TDG levels is observed with structural improvements at Green Peter and Foster. |
| McKenzie | Cougar would have negligible effects to downstream water temperatures as there are no water temperature measures. A beneficial effect to TDG is observed when including structural improvement measure at Cougar. |
| Middle Fork Willamette | Hills Creek and Dexter downstream water temperatures would observe beneficial to adverse effects. Fall Creek temperatures would remain as described in the NAA. A negligible effect is observed when including structural improvements for TDG at Hills Creek, Lookout Point, and Dexter dams. |
| Coast Fork Willamette & Long Tom | There are no water temperature measures considered at Cottage Grove, Dorena, and Fern Ridge therefore conditions would remain similar to the NAA. Although reservoir pool elevations would stay higher throughout the summer, more water would be released September through October. There are no measures considered for TDG management therefore conditions would remain similar to the NAA. |
| Mainstem Willamette | Albany and Salem water temperatures observe an adverse effect of days below 18C (64F) during the summer as compared to the NAA. TDG gages are not located on the Willamette River as TDG concerns are typically located downstream of WVS dams. There is a negligible potential for changes in sediment supply relative to the NAA in the Middle Willamette free-flowing reach as such Turbidity is not expected to increase. HABs are not expected as there are no OHA advisories near Albany and Salem in public records. |

**<u>Water Temperature</u>**

Alternative 1 would include measures with structural improvements for water temperature include water temperature control towers (selective water withdrawal structures) at Detroit, Green Peter, and Lookout Point dams. Detroit, Green Peter and Lookout Point dams. Implementation of these measures would see a Beneficial or Negligible effect (Appendix D Figure 1-383; Table 3.5-10). Additionally, a measure to modify existing outlets, which would allow releases at varying depths for temperature control at Foster dam through a Facility Warm Water Supply (FWWS) pipe and fish weirs, is included in Alternative 1. Foster dam water temperatures would see a Beneficial or Negligible effect.

**Table 3.5-11. 3-year Average temperature difference with Effects Criteria of Alternative 1 as compared to NAA.**

| Location | Difference from NAA in Days Below 18C each year | Days Below 18C Effects Criteria | Annual Average Number of Days within 2 degrees F of Temperature Target (Apr-Aug) | Days Near Target (Apr-Aug) Effects Criteria | Annual Average Number of Days within 2 degrees F of Temperature Target (Sep-Mar) | Days Near Target (Sep-Mar) Effects Criteria |
|---|---|---|---|---|---|---|
| HCRO | -6 | Minor Adverse | -6 | Negligible | 0 | Negligible |
| DEXO | -9 | Moderate Adverse | 10 | Minor Benefit | -3 | Negligible |
| CGRO | 0 | Negligible | -1 | Negligible | -1 | Negligible |
| SSFO | -35 | Major Adverse | 43 | Moderate Benefit | -9 | Negligible |
| BCLO | 0 | Negligible | 42 | Moderate Benefit | 55 | Major Benefit |
| ALBO | -5 | Minor Adverse | NA | | NA | |
| SLMO | -8 | Minor Adverse | NA | | NA | |

Please refer to Technical Appendix D for all Temperature model results by Alternative

NA is due to no temperature targets for the Willamette during this period

**TDG**

Alternative 1 includes structural improvement measures to reduce TDG at Detroit, Big Cliff, Green Peter, Foster, Lookout Point, Dexter, and Cougar dams. Detroit dam would potentially have a Moderate Benefit. Cougar dam would have a potential Minor Benefit from structural improvements for TDG. A Negligible effect would be observed at Green Peter, Foster, Hills Creek, Lookout Point, and Dexter dams (Figure 3.5-57; Table 3.5-11). Please refer to the Water Quality Technical Appendix D for further data formulas and results, such as boxplot figures of TDG by Alternative compared to the NAA.

**Table 3.5-12. Compilation of TDG model results (Appendix D Figures 2-35;2-36;2-34; Figure 3.5-57) downstream of the dams for Alternative 1.**

| Location | Average Number of Days Above 110% TDG | Annual Difference in Number of Days Above 110 % TDG compared to the No Action Alternative | Average Number of Days with Spill Per Year | Magnitude of Effects |
|---|---|---|---|---|
| DEX | 5 | -15 | 89 | Negligible |
| LOP | 0 | 0 | 51 | Negligible |
| HCR | 9 | -9 | 93 | Negligible |
| CGR | 16 | -41 | 160 | Minor Benefit |
| FOS | 20 | -12 | 285 | Negligible |
| GPR | 13 | 0 | 48 | Negligible |
| BCL | 31 | -117 | 88 | Major Benefit |
| DET | 39 | -77 | 62 | Moderate Benefit |

**Turbidity**

There are no measures for Turbidity however sites are qualitatively described in the below sections. Potential Changes in Sediment Supply within the River Mechanics and Geomorphology Section 3.3 and Technical Appendix C is utilized.

**HABs**

There are no measures for Harmful Algae Blooms however sites are qualitatively described in the below sections. River Mechanics and Geomorphology analysis of Head-of-Reservoir, Shoreline Exposure and Sediment Re-Entrainment and Bank Failure Potential within Section 3.3 and Technical Appendix C of is utilized. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury; however, sites are qualitatively described in the below sections. Shoreline Exposure analysis within the River Mechanics and Geomorphology Section 3.3 and Technical Appendix C is utilized.

### *3.5.2.4 Alternative 2A -- Hybrid Alternative*

This section describes the Alternative 2A effects to water quality.

#### *3.5.2.4.1 North Santiam Dams*

**Water Temperature**

North Santiam sub-basin would include a Water Temperature Control tower at Detroit reservoir for water temperature management for Alternative 2A. Big Cliff/ Detroit Dams would have a Negligible effect of days below 18C (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Major Benefit for Days Near Temperature Target from September through March (Figure 3.5-56; Table 3.5-14).

Alternative 2A results as compared to the NAA the Monthly Mean of Daily Mean water temperatures at the North Santiam at Niagara gaging site (BCLO; Appendix D Figure 1-390) in the 2011-year scenario would increase in water temperatures up to 4 degrees from June to October. In the 2015-year scenario water temperatures would increase up to 3 degrees from May until August and then a 4–6-degree decrease is observed in September and October. In the 2016-year scenario water temperatures increase up to 11 degrees from May to September and then a 2-degree decrease is observed in October. For the Average of the three years a water temperature increase up to 6 degrees is observed May to September and then a 2-degree decrease is observed in October.

**TDG**

There are no TDG abatement measures under Alternative 2A for Detroit and Big Cliff dams. A Moderate Beneficial effect is observed under Alternative 2A as compared to the NAA for Detroit and Big Cliff (Figure 3.5-57; Table 3.5-15).

Under Alternative 2A, Detroit reservoir is observed to have 39 average number of days above 110% TDG levels and Big Cliff is 80 average number of days. Detroit reservoir is reduced by 77 days and Big Cliff has a reduction in 69 Annual difference in number of days above 110% of TDG exceedances as compared to the No Action Alternative. The Average Number of Days of Spill per year at Detroit is 62 days and Big Cliff is 87 days.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to Section 3.3.2.4 River Mechanics and Geomorphology Potential for changes in sediment supply for the North Santiam are described as having a Moderate change in sediment supply with additional fine-grained sediments passing into Big Cliff run-of river reservoir. Increased fine-grained sediment supply is due deeper drafts in Detroit Reservoir that have the potential to pass sediment through Detroit Dam and partially through the Big Cliff run-of-river reservoir. There is the potential for a Minor change in fine-grained sediment supply to the North Fork Santiam River downstream of Big Cliff Dam.

**HABS**

There are no measures for HABs within Detroit. Please refer to River Mechanics and Geomorphology Section 3.3.2.4 and Technical Appendix C, Alternative 2A has Negligible effect in the potential for head-of-reservoir sediment mobilization relative to the NAA due to changes in operations at Detroit reservoir. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C result in a Major change for Detroit reservoir relative to the NAA. Sediment Re-Entrainment and Bank Failure Potential metric would have a Major change for Detroit reservoir. Big Cliff reservoir is a run-of river project that operates in a small range of pool elevations and is not included for these metrics. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Detroit. Big Cliff reservoir is a run-of river project that operates in a small range of pool elevations and is not included for this metric. Please refer River Mechanics and Geomorphology Section 3.3.2.4 for the qualitative analysis of Alternative 2A as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Detroit dam. Currently the amount or levels of mercury in Detroit reservoir is unknown. As there is Major change in shoreline exposure at Detroit dam there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.4.2 South Santiam Dams*

**Water Temperature**

Alternative 2A includes the use of the RO’s to discharge colder water during fall and winter drawdown operations at Green Peter reservoir. Another measure includes the use of the spillway for surface spill in the summer at Green Peter reservoir. A measure to modify existing outlets to allow releases at varying depths for temperature control specifically at Foster reservoir through a Facility Warm Water Supply (FWWS) pipe and fish weirs. Green Peter/Foster Dams would see a Major Adverse effect for Days below 18 C (64.4 F) (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Minor Benefit for Days Near Temperature Target from September through March (Figure 3.5-56; Table 3.5-14).

Results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the South Santiam River near Foster gaging site (SSFO; Appendix D Figure 1-392) in the 2011-year scenario would see an increase starting in May through October up to 10 degrees. In the 2015-year scenario an increase of 1 to 5 degrees from April to July and then decrease from 2 to 4 degrees from August to October. In the 2016-year scenario an increase up to 10 degrees from April to September and then decrease by 1 degree in October. For the Average of the three years (2011, 2015, 2016) an increase 1 to 6 degrees from April through September and then decrease by 2 degrees in October.

**TDG**

There are no TDG management measures for Green Peter and Foster dams under Alternative 2A. Green Peter would have a Major Adverse effect and Foster would result in a Moderate Adverse effect (Figure 3.5-57; Table 3.5-15).

Under Alternative 2A, the average number of days above 110% TDG levels at Green Peter is 151 days and Foster is 126 days. Green Peter has an increase of 139 days of TDG exceedances and Foster is increased by 94 days as compared to the No Action Alternative. The Average Number of Days of Spill per year at Green Peter is 190 days and Foster is 284 days. The increase in average number of days with spill per year likely contributes to the adverse effects.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to Section 3.3.2.4 River Mechanics and Geomorphology for Alternative 2A the Potential for Sediment Supply has Increased fine-grained sediment supply is due deeper drafts in Green Peter Reservoir that create Major potential for bank erosion and sloughing generating sediment that may pass due to concurrent reduction in reservoir storage volume. There is the potential for a Moderate change in fine-grained sediment supply to the South Fork Santiam downstream of Foster Dam with additional fine-grained sediment passing the dam.

**HABS**

Please refer to the Section 3.5 Water Quality Affected Environment. Please refer to River Mechanics and Geomorphology Section 3.3.2.4 “Alternative 2A would have a Major change at Green Peter and Minor change at Foster in the potential for head-of-reservoir sediment mobilization relative to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Green Peter reservoir and Negligible for Foster reservoir. Sediment Re-Entrainment and Bank Failure Potential metric would have a Major change for Green Peter reservoir and Negligible for Foster reservoir. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Green Peter and Foster. Please refer River Mechanics and Geomorphology Section 3.3.2.3.2 for the qualitative analysis of Alternative 2A as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Green Peter reservoir and Negligible for Foster reservoir. Currently the amount or levels of mercury in Green Peter and Foster reservoirs is unknown. As there is Major change in shoreline exposure at Green Peter dam there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.4.3 McKenzie Dams*

**Water Temperature**

There are no water temperature measures for Cougar or Blue River dams under Alternative 2A. South Fork McKenzie River near Rainbow site (CGRO) is downstream of Blue River and Cougar Dam and would see a Negligible effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March (Figure 3.5-56; Table 3.5-14).

Results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the South Fork McKenzie River near Rainbow gaging site (CGRO; Appendix D Figure 1-393) in the 2011-year scenario there would be a decrease of 1-degree observed from May until August as compared to the NAA. In the 2015-year scenario a decrease up to 3-degrees is observed from June until August, as compared to the NAA. In the 2016-year scenario a decrease is observed up to 2 degrees in June and July, an increase is observed in September as compared to the NAA. For the Average of the three years (2011, 2015, 2016) a decrease up to 2-degrees is observed from June until August as compared to the NAA.

**TDG**

There are no TDG management measures for Cougar or Blue River Reservoirs. Cougar reservoir would have a Negligible effect with Alternative 2A measures as compared to the NAA (Figure 3.5-57; Table 3.5-15).

Under Alternative 2A, the average number of days above 110% TDG levels at Cougar is 54 days (Appendix D Figure 2-35). Observing the Annual difference in number of days above 110% of TDG exceedance Cougar is decreased by 3 days as compared to the No Action Alternative (Figure 2-36). The Average Number of Days of Spill per year at Cougar is 168 days (Appendix D Figure 2-34).

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. In section 3.3.2.4 River Mechanics and Geomorphology for Alternative 2A the Potential for changes in sediment supply describes "a Minor change in sediment supply with additional fine-grained sediments passing out of Cougar downstream into the McKenzie River. Increased fine-grained sediment supply is due to deeper drafts that may pass fine-grained sediment out of Cougar Reservoir. Blue River reservoir would have a potential for a Moderate change in fine-grained sediment supply as compared to the NAA. Increased fine-grained sediment supply is due to deeper drafts in Blue River increasing the potential for bank erosion and sloughing generating sediment in the reservoir that may pass the dam due to a concurrent reduction in reservoir storage volume.

**HABS**

Please refer to the Section 3.5 Water Quality Affected Environment. The River Mechanics and Geomorphology Section 3.3.2.3 concludes that Alternative 2A has Negligible effect in the potential for head-of-reservoir sediment mobilization relative to the NAA due to changes in operations at Cougar reservoir. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C result in a Major change for Cougar and Blue River dams. Sediment Re-Entrainment and Bank Failure Potential metric result in a Moderate change for Cougar dam and Major change for Blue River. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Cougar and Blue River. Please refer to River Mechanics and Geomorphology Section 3.3.2.4 for the qualitative analysis of Alternative 2A as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Cougar and Blue River dams. Currently the amount or levels of mercury in Cougar and Blue River is unknown. As there is Major change in shoreline exposure at Cougar and Blue River dams there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.4.4 Middle Fork Willamette Dams*

**Water Temperature**

Alternative 2A has no water temperature measures for the Middle Fork sub-basin. Lookout Point/Dexter Dams would see a Negligible effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March (Figure 3.5-56; Table 3.5-14).

Results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the Middle Fork Willamette River near Dexter gaging site (DEXO; Appendix D Figure 1-394) in the 2011-year scenario would see an increase starting in May through September up to 6 degrees and decrease by 6 degrees in October. In the 2015-year scenario: increase up to 4 degrees from April to June and then decrease by 4 degrees from July to October. In the 2016-year scenario an increase up to 6 degrees from April to August and then decrease by 6 degrees in October. For the Average of the three years (2011, 2015, 2016): increase up to 3 degrees from April to August and then decrease by 5 degrees in October.

Hills Creek dam would see a Moderate Adverse effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5-14)).

As compared to the NAA the Monthly Mean of Daily Mean water temperatures (deg F) at the Middle Fork Willamette River above Salt Creek gaging site (HCRO; Appendix D Figure 1-395) in the 2011-year scenario there would be no temperature difference from April until September and decrease by 1 degree in October as compared to the NAA. In the 2015-year scenario a decrease by 3 degrees from April to June, increase by 3 degrees in July to September, decrease by 3 degrees in October. In the 2016-year scenario there would be no temperature change observed in April and then a decrease observed up to 5 degrees from May until October. For the Average of the three years (2011, 2015, 2016) a temperature decrease up to 2 degrees is observed in May, June, and October.

**<u>TDG</u>**

There are no TDG measures within Alternative 2A for Hills Creek, Lookout Point, and Dexter dams although model analysis has determined Negligible effects to the sub-basin (Figure 3.5-57; Table 3.5-15). Fall Creek reservoir does not have a TDG gage and effects would be similar to the Affected Environment section 3.5.

Under Alternative 2A, Lookout Point has reduction of 0 days and on average 0 days of TDG exceedance for the year (Appendix D Figure 2-35). Dexter dam is reduced by 0 days and exceeds TDG by 20 days by average number of days (Figure 2-36). Hills Creek dam has a reduction of 1 day of Annual Difference in Number of Days above 110% and on average number of days exceeds TDG by 18 days as compared to the No Action Alternative. The Average Number of Days of Spill per year at Hills Creek is 121 days, Lookout Point is 48 days, and Dexter is 91 days (Appendix D Figure 2-34).

**<u>Turbidity</u>**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.4.2 for Alternative 2A for Potential for Sediment Supply there is a Moderate change in sediment supply with additional fine-grained sediments passing out of Hills Creek into the Middle Fork Willamette above Lookout Point. Increased fine-grained sediment supply is due deeper drafts that may pass fine-grained sediment out of Hills Creek Reservoir and deposit within Lookout Point reservoir. Dexter reservoir would have a potential for a Minor change in fine-grained sediment supply. Downstream of Dexter Dam there would be a Negligible potential for change in sediment supply.

**HABS**

Please refer to the Section 3.5 Water Quality Affected Environment. In River Mechanics and Geomorphology Section 3.3.2.4 "Alternative 2A has Negligible change in the potential for head-of-reservoir sediment mobilization at Hills Creek, Lookout Point and Fall Creek. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Hills Creek and Lookout Point. Fall Creek reservoir would see a Negligible change. Sediment Re-Entrainment and Bank Failure Potential metric would have a Major change for Hills Creek, Minor change for Lookout Point, Negligible change for Fall Creek reservoir. Dexter reservoir is a run-of river project that operates in a small range of pool elevations and is not included in these metrics. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Hills Creek, Lookout Point and Fall Creek. Please refer River Mechanics and Geomorphology Section 3.3.2.4 for the qualitative analysis of Alternative 1 as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Hills Creek and Lookout Point. Fall Creek reservoir would have a Negligible change. Dexter reservoir is a run-of river project that operates in a small range of pool elevations and is not included in this metric. Currently it is Currently the amount or levels of mercury in Hills Creek, Lookout Point, and Fall Creek is unknown. As there would be a Major change in shoreline exposure at Hills Creek and Lookout Point dams there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.4.5 Coast Fork Dams and Long Tom*

**Water Temperature**

There are no measures at Cottage Grove, Dorena and Fern Ridge dams under Alternative 2A, water temperatures would remain as described in the No Action Alternative and Water Quality Affected Environment section 3.5.

**TDG**

There are no measures at Cottage Grove, Dorena dams under Alternative 2A, TDG would remain unchanged and similar to the No Action Alternative and Water Quality Affected Environment. TDG exceedance may occur if water is released through the non-turbine outlets of dams, spill and maintenance operations.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.4 Alternative 2A would have a Negligible potential for changes in sediment supply relative to the No Action Alternative in the Coast Fork of the Willamette River and Row River free-flowing reaches and Long Tom free-flowing reach.

**HABS**

Please refer to River Mechanics and Geomorphology Section 3.3.2.4 and Technical Appendix C Alternative 2A would have a Negligible change in the potential for head-of-reservoir sediment mobilization relative to the NAA due to changes in operations at Detroit reservoir. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Negligible change for Cottage Grove, Dorena, and Fern Ridge reservoirs. Sediment Re-Entrainment and Bank Failure Potential metric would have a Negligible change for Cottage Grove, Dorena, and Fern Ridge reservoirs. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Cottage Grove, Dorena, and Fern Ridge dams. However, referencing River Mechanics and Geomorphology Section 3.3.2.4 states that *"*Alternative 2A would have a Negligible change in shoreline exposure relative to the NAA for Cottage Grove, Dorena, and Fern Ridge Dams. Technical Appendix C Table 4-5 indicates a difference in shoreline exposure at Minimum Operating Pool of 0.0 ft at Cottage Grove, Dorena, and Fern Ridge Dams. Mercury has been studied in Cottage Grove and Dorena Dams as Total Mercury (inorganic) and Methylated Mercury (organic) in sediment Ambers et al. 2001; Eckley et al. 2015; Eckley et al. 2017). Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.4.6 Mainstem Willamette River*

**Water Temperature**

Alternative 2A water temperature results for the Mainstem Willamette River at Salem (SLMO) results in a Negligible effect for Days below 18 C (64.4 F) (Summer). Results are not reported for "Days Near Temperature Target from April through August" or "Days Near Temperature Target from September through March" because there are no temperature targets (Figure 3.5-56; Table 3.5-14).

Mainstem Willamette River results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the Willamette River near Salem gaging site (SLMO; Appendix D Figure 1-390) in the 2011-year scenario there would be a 1-degree water temperature increase in August. In the 2015-year scenario water temperatures increase up to 2-degree in April and May and then decrease up to 2 degrees from July until September. In the 2016-year scenario a water temperature increase of 1 degree is observed in May. For the Average of the three years (2011, 2015, 2016) water temperature increases 1-degree in May and then decreases by 1 degree in July and September.

Alternative 2A water temperature results for the Mainstem Willamette River at Albany (ALBO) results in a Negligible effect for Days below 18 C (64.4 F) (Summer). Results are not reported for "Days Near Temperature Target from April through August" or "Days Near Temperature Target from September through March" because there are no temperature targets (Figure 3.5-56; Table 3.5-14).

Mainstem Willamette River results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the Willamette River at Albany gaging site (ALBO; Appendix D Figure 1-390) in the 2011-year scenario a water temperature increase up to 1 degree is observed in August. In the 2015-year scenario a water temperature increase of 1 degree is observed in April and May and then 1 degree decrease in June and July. In the 2016-year scenario a water temperature increase of 1-degree is observed in May. For the Average of the three years (2011, 2015, 2016) a water temperature increase up to 1-degree is observed in May.

**TDG**

To the USACE knowledge, there are no TDG gages located on the Willamette River and TDG is presumed not to be an issue, as this is a water quality parameter most affected by dam operations. Therefore, TDG gages are typically located downstream of WVS projects where there are known issues.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.4 and Technical Appendix C for Potential for changes in sediment supply "there is Negligible potential for changes in sediment supply relative to the No Action Alternative in the Middle Willamette free-flowing reach".

**HABs**

To the USACE knowledge, there have been no OHA advisories near Albany and Salem. At this time the USACE cannot control cyanobacteria bloom formation and growth. Further research is needed to determine factors that assist in toxin production and toxin suppression.

*3.5.2.4.7 Climate Change*

Please reference Technical Appendices B and F for Climate Change qualitative effects. Compared to NAA, Alternative 2A would potentially have more resiliency against climate change effects on water temperature (increased water temperature control) below Detroit and Green Peter as a result of the proposed SWS and operational temperature control measures at those locations. TDG effects immediately below Detroit would likely be more resilient to climate change under Alternative 2A due to the proposed SWS (reducing the need for operational temperature control). Parameters such as Turbidity and Mercury will likely experience similar effects as those described under NAA. Increased releases from the lake surface via the proposed SWS at Detroit combined with reduced summer flow volumes under Alternative 2A could lead to increased phytoplankton (algae) compared to NAA (Technical Appendix B Hydrology and Hydraulics).

**Table 3.5-13. Summary of Effects of Alternative 2A as compared to the NAA**

| Subbasin | Alternative 2A |
|---|---|
| North Santiam | Big Cliff observes a negligible to beneficial effect for water temperatures with the inclusion of a Water Temperature Control tower at Detroit dam. A beneficial effect to TDG levels is observed at Detroit and Big Cliff. |
| South Santiam | Foster observes negligible to beneficial effects to downstream water temperatures. Adverse effects to TDG levels are observed at Green Peter and Foster. |
| McKenzie | Cougar would have negligible effects to downstream water temperature. A negligible effect to TDG is observed when including structural improvement at Cougar. Blue River is not expected to change as the RO's are utilized and TDG levels would not be expected to change. |
| Middle Fork Willamette | Hills Creek downstream water temperatures would observe an adverse to negligible effect. Dexter downstream water temperatures would observe negligible, beneficial, and adverse effects to downstream water temperatures. Fall Creek temperatures would remain as described in the NAA. A negligible effect is observed for TDG at Hills Creek, Lookout Point, and Dexter dams. |
| Coast Fork Willamette & Long Tom | There are no water temperature measures considered at Cottage Grove, Dorena, and Fern Ridge therefore conditions would remain similar to the NAA. There are no measures considered for TDG management therefore conditions would remain similar to the NAA. |
| Mainstem Willamette | Albany and Salem water temperatures observe negligible effects as compared to the NAA. Water quality parameters such as TDG, Turbidity, HABs are negligible or have not been reported as a concern. |

#### *3.5.2.4.8 Evaluation of Near-Term Operations Measures*

Please refer to Chapter 2 for descriptions of the Near-Term Operations Measures. A qualitative description of the near-term operations measure impacts to water quality parameters is provided by sub-basins. The descriptions of the Near-Term Operations can be found within Section 2.2.5, Suite of Near-term Operations. Table 3.2-13 summarizes the analysis of effects of the near-term operations on water quality by subbasins.

**North Santiam Dams**

The Near-Term Operations Measures in the North Santiam include Detroit Fall/Winter Downstream Fish Passage, Detroit Spring Downstream Fish Passage, and Big Cliff Spread Spill for TDG Abatement.

***Water Temperature***

The Near-Term Operations Measure in the fall at Detroit Dam would have no effect to downstream water temperatures.

The Near-Term Operations Measures that occur in the spring at Detroit Dam would be an improvement to downstream water temperatures as compared to the NAA (section 3.6.3.1.1). This operation does not apply a 60% spill cap (whereas the NAA does) and therefore as much water as necessary can be spilled through non turbine outlets to meet the downstream water temperature targets. Instead, downstream water temperature and TDG conditions are used to cap spill.

No effects to downstream water temperatures at Big Cliff are expected with the Near-Term Operating Measure.

***TDG***

The Near-Term Operations Measure in the Fall/Winter and Spring at Detroit may result in elevated TDG levels downstream of Detroit dam when water is discharged through the Upper Regulating Outlets (UROs) and Lower Regulating Outlets (LROs) for downstream fish passage and water temperature management. The use of RO's or non-turbine outlets may elevate TDG levels downstream of Detroit Dam and limit the ability to meet downstream water temperature targets at times. Use of the turbines during the day will help to reduce TDG levels created at night.

The Near-Term Operations Measure at Big Cliff may improve TDG levels but has limitations. When spill is necessary at Big Cliff Dam, some benefit can be realized from spreading spill across the spillway, using multiple spill bays; however, minimum gate opening constraints preclude from spreading spill under all flow regimes. Additionally, TDG is also generated by Detroit Dam operations, particularly when a non-turbine unit is used to discharge water. In this case, spreading spill at Big Cliff Dam does not prevent or abate TDG exceedances that are generated by Detroit Dam.

***Turbidity***

Please refer to River Mechanics and Geomorphology Evaluation of Near-Term Operations Measure for Potential for changes in sediment supply effects based on integrated operations.

***HABs***

Please refer to River Mechanics and Geomorphology Evaluation of Near-Term Operations Measure for Head-of-Reservoir, Shoreline Exposure, Sediment Re-Entrainment/Bank Failure effects based on integrated operations for the Near-Term Operations Measure.

**<u>South Santiam Dams</u>**

The Near-Term Operations Measure in the South Santiam include Green Peter Outplanting Plan, Green Peter Spring Downstream Fish Passage, Green Peter Fall Downstream Fish Passage, Foster Spring Downstream Fish Passage, Foster Fall Downstream Fish Passage.

The Near-Term Operations Measure which includes the Green Peter Outplanting Plan would have no effect on water quality.

***Water Temperature***

The Near-Term Operations Measure in the spring at Green Peter may result in improved water temperatures as the spillway will release warmer water temperatures downstream of Green Peter Dam, mimicking unregulated systems more closely, as compared to the NAA. The Near-Term Operations Measure in the fall at Green Peter may result in warmer downstream water temperatures in the fall and winter from early drawdown operations of Green Peter Reservoir. These effects would be limited to the Middle Santiam. Foster Reservoir would likely help alleviate the warmer water temperature impacts.

The Near-Term Operations Measure in the spring at Foster may result in an improvement to downstream water temperatures due to delayed refill operations. The use of the Foster fish weir will also aid in improving water temperatures. The Near-Term Operations Measure in the fall at Foster may result in an improvement to downstream water temperatures due to utilizing the spillway to provide more normative water temperatures.

***TDG***

The Near-Term Operations Measure in the spring at Green Peter may result in elevated TDG levels downstream of Green Peter dam with the preferential use of non-turbine outlets. Non-turbine outlets are known to elevate TDG levels. The Near-Term Operations Measure in the fall at Green Peter may result in elevated TDG levels during drawdown and once the reservoir is held at El. 780 ft. Rain events may necessitate the need to release large amounts of water downstream in order to hold the reservoir at 780 ft elevation. These high flows may cause elevated TDG.

The Near-Term Operations Measure in the spring at Foster may result in elevated TDG levels as water releases occur through non turbine outlets. Non-turbine outlets are known to elevate TDG levels. The Near-Term Operations Measure that occur in the fall at Foster may result in elevated TDG levels when flows are high. Elevated TDG levels could occur if releases are greater than 3000 cfs.

***Turbidity***

Please refer to River Mechanics and Geomorphology Evaluation of Near-Term Operations Measure for Potential for changes in sediment supply effects based on integrated operations.

***HABs***

Please refer to River Mechanics and Geomorphology Evaluation of Near-Term Operations Measure for Head-of-Reservoir, Shoreline Exposure, Sediment Re-Entrainment/Bank Failure effects based on integrated operations for the Near-Term Operations Measure.

**McKenzie Dams**

The Near-Term Operations Measure within the McKenzie include Cougar Fall Drawdown for Downstream Fish Passage, Cougar Spring Drawdown for Downstream Fish Passage. There are no proposed operations at Blue River in the Near-Term Operations Measure.

***Water Temperature***

The Near-Term Operations Measure at Cougar in the fall is not likely to affect downstream water temperatures as the implementation occurs during the fall and winter when water temperatures are cool. The Near-Term Operations Measure at Cougar in the spring may result in downstream water temperature management not being implemented if refill does not occur. The Water Temperature Control Tower weirs can provide temperature control at or above 1571ft elevation.

Please refer to Section 3.2.1.1.3 Hydrologic Processes for the McKenzie sub-basin based on integrated operations for the Near-Term Operations Measure.

***TDG***

The Near-Term Operations Measure at Cougar in the fall may result in elevated TDG levels while keeping the reservoir at the 1505 ft elevation. Rain events may necessitate the release of high amounts of water through the RO’s to keep the 1505 ft elevation. The Cougar RO’s are known to produce elevated TDG levels when releases are in excess of 800 cfs. The Near-Term Operations Measure at Cougar in the spring may result in elevated TDG levels due to holding Cougar Reservoir at a delayed refill state (1520-1532 ft). Rain events may necessitate the release of water to keep the 1520 – 1532 ft elevation, this water release may cause higher flow and elevate TDG levels.

Please refer to Hydrologic Processes for the McKenzie sub-basin based on integrated operations for the Near-Term Operations Measure.

***Turbidity***

Please refer to River Mechanics and Geomorphology Evaluation of Near-Term Operations Measure for changes in sediment supply effects based on integrated operations.

***HABs***

Please refer to River Mechanics and Geomorphology Evaluation of Near-Term Operations Measure for Head-of-Reservoir, Shoreline Exposure, Sediment Re-Entrainment/Bank Failure effects based on integrated operations.

**Middle Fork Willamette Dams**

The Near-Term Operations Measure in the Middle Fork Willamette include Hills Creek Downstream Fish Passage, Lookout Point Winter Downstream Passage Operations, Lookout Point Spring and Fall Downstream Passage Operations, Fall Creek Fall/Winter Downstream Passage Operations, and Fall Creek Spring Downstream Passage Operations.

***Water Temperature***

No downstream water temperature effects are expected at Hills Creek with Near-Term Operations Measure due to timing of the operation in the winter.

The Near-Term Operations Measure at Lookout Point in the winter may result in warmer downstream water temperatures in the fall due to an earlier drawdown operation of Lookout Point Reservoir. The Near-Term Operations Measure at Lookout Point in the spring and fall may result in improved spring and early summer downstream water temperatures. The use of the RO's in the late summer and fall may also improve downstream water temperatures, however past data suggests that cold water is limited in Lookout Point Reservoir and use of the RO may not be as beneficial as the temperature management observed from operational temperature management that is implemented at Detroit Dam.

The Near-Term Operations Measure at Fall Creek would not impact downstream water temperatures in the fall and winter when water temperatures are cool. Operations in the spring may impact downstream water temperatures due to delayed refill, low reservoir elevations, and inability to use all fish horns (El. 3-720 ft, 3-765 ft, 3-800 ft). The fish horns are utilized for water temperature management.

***TDG***

No TDG effects are expected with the Near-Term Operating Measure at Hills Creek, as the regulating outlets at Hills Creek Dam are not known to produce elevated TDG.

The Near-Term Operations Measure at Lookout Point in the winter may result in elevated TDG levels during drawdown and once the reservoir is being held at El. 750 ft. Rain events may necessitate the need to release large amounts of water downstream in order to hold the reservoir at 780 ft elevation. These high flows and use of non-turbine outlets may result in elevated TDG. The Near-Term Operations Measure at Lookout Point in the spring and fall may result in elevated TDG levels with use of non-turbine outlets. Rain events may necessitate the release of large amounts of water which may cause elevated TDG levels when the water is released through non-turbine outlets.

The Near-Term Operations Measure at Fall Creek in the fall and spring may elevate TDG levels during high flow events and releasing water in order to keep the reservoir at specific elevation. Rain events may necessitate the release of water which may cause elevated TDG levels.

***Turbidity***

Please refer to River Mechanics and Geomorphology Evaluation of Near-Term Operations Measure for changes in sediment supply effects based on integrated operations.

***HABs***

Please refer to River Mechanics and Geomorphology Evaluation of Near-Term Operations Measure for Head-of-Reservoir, Shoreline Exposure, Sediment Re-Entrainment/Bank Failure effects based on integrated operations.

**Coast Fork Dams**

There are no proposed operations in the Coast Fork sub-basin in the Near-Term Operations Measure, therefore, there would be no effects of this measure to water quality. Please refer to Section 3.3.3.3 River Mechanics and Geomorphology and Section 3.2.1.1 Hydrologic Processes for further information.

**Mainstem Willamette**

***Water Temperature***

Please refer to Hydrologic Processes for Albany and Salem flow information.

***TDG***

To the USACE knowledge, there are no TDG gages located on the Willamette River and TDG is presumed not to be an issue, as this is a water quality parameter most affected by dam operations. Therefore, TDG gages are typically located downstream of WVS projects where there are known issues.

***Turbidity***

Please refer to River Mechanics and Geomorphology Evaluation of Near-Term Operations Measure for Potential for changes in sediment supply effects based on integrated operations.

***HABs***

To the USACE knowledge, there are no OHA HAB advisories near Albany and Salem in public records. At this time the USACE cannot control cyanobacteria bloom formation and growth. Further research is needed to determine factors that assist in toxin production and toxin suppression.

3.5.2.4.9 Summary of Effects

Below is provided a summary of Alternative 2A's overall water quality effects.

**Water Temperature**

A summary of Alternative 2A measures for structural improvements of water temperature at the WVS dams includes: Water temperature control tower at Detroit reservoir; Use the RO's to discharge colder water during fall and winter drawdown operations at Green Peter reservoir; Use of the spillway for surface spill in the summer at Green Peter reservoir; Modifications to increase warm water releases through a Facility Warm Water Supply (FWWS) pipe and fish weir at Foster Dam. Detroit, Green Peter and Foster Point dams result in a Beneficial or Negligible effect (Figure 3.5-56; Table 3.5-14). Monthly Mean of Daily Mean Water Temperature difference from the NAA to Alternative 2A can be found in Appendix D Figure 1-390. Please refer to Technical Appendix D for figures of temperature model results.

**Table 3.5-14. 3-year Average temperature difference with Effects Criteria of Alternative 2A as compared to NAA.**

| Location | Difference from NAA in Days Below 18C each year | Days Below 18C Effects Criteria | Annual Average Number of Days within 2 degrees F of Temperature Target (Apr-Aug) | Days Near Target (Apr-Aug) Effects Criteria | Annual Average Number of Days within 2 degrees F of Temperature Target (Sep-Mar) | Days Near Target (Sep-Mar) Effects Criteria |
|---|---|---|---|---|---|---|
| HCRO | -14 | Moderate Adverse | -6 | Negligible | 3 | Negligible |
| DEXO | 4 | Negligible | 2 | Negligible | 3 | Negligible |
| CGRO | 0 | Negligible | 3 | Negligible | -1 | Negligible |
| SSFO | 3 | Negligible | 31 | Moderate Benefit | 17 | Minor Benefit |
| BCLO | 0 | Negligible | 42 | Moderate Benefit | 57 | Major Benefit |
| ALBO | 0 | Negligible | NA | | NA | |
| SLMO | 0 | Negligible | NA | | NA | |

Please refer to Technical Appendix D for all Temperature model results by Alternative.
NA is due to no temperature targets for the Willamette during this period.

**TDG**

Under Alternative 2A, there are no measures to reduce TDG at the WVS dams. A Major Adverse effect is observed at Green Peter reservoir and a Moderate Adverse effect is observed at Foster reservoir. Detroit and Big Cliff dams would have a Moderate Benefit. A Negligible effect would be observed at Cougar, Hills Creek, Lookout Point, and Dexter dams (Figure 3.5-57; Table 3.5-15). Please refer to the Water Quality Technical Appendix D for further data formulas and results, such as boxplot figures of TDG by Alternative compared to the NAA.

**Table 3.5-15 . Compilation of TDG model results (Appendix D, Figures 2-35;2-36;2-34; Figure 3.5-57) downstream of the dams for Alternative 2A.**

| Location | Average Number of Days Above 110% TDG | Annual Difference in Number of Days Above 110 % TDG compared to the No Action Alternative | Average Number of Days with Spill Per Year | Magnitude of Effects |
|---|---|---|---|---|
| DEX | 20 | 0 | 91 | Negligible |
| LOP | 0 | 0 | 48 | Negligible |
| HCR | 18 | -1 | 121 | Negligible |
| CGR | 54 | -3 | 168 | Negligible |
| FOS | 126 | 94 | 284 | Moderate Adverse |
| GPR | 151 | 139 | 190 | Major Adverse |
| BCL | 80 | -69 | 87 | Moderate Benefit |
| DET | 39 | -77 | 62 | Moderate Benefit |

**Turbidity**

There are no measures for Turbidity however sites are qualitatively described in the below sections. Potential Changes in Sediment Supply within the River Mechanics and Geomorphology Section 3.3 and Technical Appendix C is utilized for comparison.

**HABs**

There are no measures for Harmful Algae Blooms however sites are qualitatively described in the below sections. River Mechanics and Geomorphology analysis of Head-of-Reservoir, Shoreline Exposure and Sediment Re-Entrainment and Bank Failure Potential within Section 3.3 and Technical Appendix C of is utilized for comparison.

**Mercury**

There are no WVS EIS Alternative measures for Mercury however sites are qualitatively described in the below sections. Shoreline Exposure analysis within the River Mechanics and Geomorphology Section 3.3 and Technical Appendix C is utilized.

### *3.5.2.5 Alternative 2B -- Hybrid Alternative*

This section describes the Alternative 2B effects to water quality.

#### *3.5.2.5.1 North Santiam Dam*

**Water Temperature**

Alternative 2B includes a Water Temperature Control tower at Detroit Reservoir for water temperature management. Big Cliff/ Detroit Dams would have a Negligible effect of days below 18C (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Major Benefit for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5-17).

Alternative 2B as compared to the NAA the Monthly Mean of Daily Mean water temperatures at the North Santiam at Niagara gaging site (BCLO) in the 2011-year scenario an increase up to 3-degrees is observed from June until October as compared to the NAA. In the 2015-year scenario an increase up to 3-degrees is observed from May until August and then decreases up to 6 degrees in September and October. In the 2016-year scenario an increase up to 11-degrees is observed from May until September as compared to the NAA. For the Average of the three years an increase up to 6-degrees is observed from May until September and then a decrease of 2-degrees in October as compared to the NAA.

**TDG**

There are no TDG management measures for Detroit and Big Cliff Reservoirs for Alternative 2B. Detroit and Big Cliff would have a Moderate Benefit with Alternative 2B as compared to the NAA (Figure 3.5-57; Table 3.5-18).

Under Alternative 2B, the average number of days above 110% TDG levels at Big Cliff is 80 and Detroit is 39 (Appendix D Figure 2-35). Big Cliff has a reduction in 69 Annual difference in number of days above 110% of TDG exceedances and Detroit is reduced by 77 days as compared to the No Action Alternative (Appendix D Figure 2-36). The Average Number of Days of Spill per year at Detroit is 62 days and Big Cliff is 87 days (Appendix D Figure 2-34).

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to Section 3.3.2.5 River Mechanics and Geomorphology. Potential for changes in sediment supply for Alternative 2B the North Santiam are described as having a Moderate change in sediment supply with additional fine-grained sediments passing into Big Cliff run-of river reservoir. Increased fine-grained sediment supply is due deeper drafts in Detroit Reservoir that have the potential to pass sediment through Detroit Dam and partially through the Big Cliff run-of-river reservoir. There is the potential for a Minor change in fine-grained sediment supply to the North Fork Santiam River downstream of Big Cliff Dam.

**HABS**

Please refer to River Mechanics and Geomorphology Section 3.3.2.5. Alternative 2B has Negligible change in the potential for head-of-reservoir sediment mobilization relative to the NAA due to changes in operations at Detroit Reservoir. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Detroit Reservoir. Sediment Re-Entrainment and Bank Failure Potential metric would have a Major change for Detroit Reservoir. Big Cliff Reservoir is a run-of river project that operates in a small range of pool elevations and is not included for these metrics. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Detroit. Big Cliff reservoir is a run-of river project that operates in a small range of pool elevations and is not included for this metric. Please refer River Mechanics and Geomorphology Section 3.3.2.5 for the qualitative analysis of Alternative 2B as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Detroit dam. Currently the amount or levels of mercury in Detroit is unknown. As there is Major change in shoreline exposure at Detroit dam there is potential for an increase for the methylation process to occur with water fluctuations if. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.5.2 South Santiam Dams*

**Water Temperature**

Alternative 2B includes the use of the RO's to discharge colder water during fall and winter drawdown operations at Green Peter Reservoir. An additional measure includes the use of the spillway for surface spill in the summer at Green Peter Reservoir. Also, a measure to modify existing outlets to allow releases at varying depths for temperature control specifically at Foster Reservoir through a Facility Warm Water Supply (FWWS) pipe and fish weirs.

Green Peter/Foster Dams would see a Negligible effect for Days below 18 C (64.4 F) (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Minor Benefit for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5-17)).

Results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the South Santiam River near Foster gaging site (SSFO; Appendix D Figure 1-399) in the 2011-year scenario would see a water temperature increase starting in May through October up to 8 degrees, although July observed a 1-degree temperature decrease. In the 2015-year scenario an increase in water temperatures of 1 to 6 degrees from April to June, a decrease in temperatures from 1 to 13 degrees is observed from July to October. In the 2016-year scenario an increase up to 6 degrees from April to August and then decrease by 2 degrees in September and October. For the Average of the three years (2011, 2015, 2016) an increase 1 to 5 degrees from April through June and then decrease up to 3 degrees from August until October.

**TDG**

There are no TDG measures within Alternative 2B for Green Peter and Foster Reservoirs. Green Peter has a Major Adverse effect and Foster has a Moderate Adverse effect (Figure 3.5-57; Table 3.5-18).

Under Alternative 2B, the average number of days above 110% TDG levels at Green Peter is 151 days and Foster is 126 days (Appendix D Figure 2-35). Green Peter has an increase of 139 days of TDG exceedances and Foster is increased by 94 days as compared to the No Action Alternative (Appendix D Figure 2-36). The Average Number of Days of Spill per year at Green Peter is 190 days and Foster is 284 days (Appendix D Figure 2-34).

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to Section 3.3.2.5 River Mechanics and Geomorphology for Potential for changes in sediment supply for Alternative 2B as compared to the NAA for the South Santiam “a Major change in sediment supply with additional fine-grained sediments passing into Foster Reservoir. Increased fine-grained sediment supply is due deeper drafts in Green Peter Reservoir that create Major potential for bank erosion and sloughing generating sediment that may pass due to concurrent reduction in reservoir storage volume. There is the potential for a Moderate change in fine-grained sediment supply to the South Fork Santiam downstream of Foster Dam with additional fine-grained sediment passing the dam”.

Please refer to River Mechanics and Geomorphology Section 3.3.2.5. Alternative 2B would have a Major change at Green Peter and Minor change at Foster in the potential for head-of-reservoir sediment mobilization relative to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Green Peter Reservoir and Negligible for Foster Reservoir. Sediment Re-Entrainment and Bank Failure Potential metric would have a Major change for Green Peter Reservoir and Negligible for Foster Reservoir. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Green Peter and Foster. Please refer River Mechanics and Geomorphology Section 3.3.2.5 for the qualitative analysis of Alternative 2B as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Green Peter reservoir and Negligible for Foster reservoir. Currently the amount or levels of mercury in Green Peter and Foster reservoirs is unknown. As there is Major change in shoreline exposure at Green Peter dam there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.5.3 McKenzie Dams*

**Water Temperature**

There are no water temperature measures for Cougar or Blue River dams under Alternative 2B. South Fork McKenzie River near Rainbow site (CGRO) is downstream of Blue River and Cougar

Dam and has a Negligible effect for Days below 18 C (64.4 F) (Summer), Minor Benefit for Days Near Temperature Target from April through August, and Minor Benefit for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5-17).

Results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the South Fork McKenzie River near Rainbow gaging site (CGRO; Appendix D Figure 1-400) in the 2011-year scenario there would be a water temperature decrease up to 3-degrees from April through July and a 4-degree increase in October as compared to the NAA. In the 2015-year scenario a water temperature decrease up to 7-degrees is observed from June until October, as compared to the NAA. In the 2016-year scenario a temperature decrease is observed up to 5 degrees from May until October as compared to the NAA. For the Average of the three years (2011, 2015, 2016) a temperature decrease up to 4-degrees is observed from May until October as compared to the NAA.

**TDG**

There are no TDG management measures for Alternative 2B for Cougar Reservoir. Cougar Reservoir has a Minor Benefit effect with Alternative 2B measures (Figure 3.5-57; Table 3.5-18).

Under Alternative 2B, the average number of days above 110% TDG levels at Cougar is 27 days (Appendix D Figure 2-35). Observing the Annual difference in number of days above 110% of TDG exceedance Cougar is decreased by 30 days as compared to the No Action Alternative (Appendix D Figure 2-36). The Average Number of Days of Spill per year at Cougar is 46 days (Appendix D Figure 2-34).

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. In section 3.3.2.5 River Mechanics and Geomorphology for Alternative 2B the Potential for changes in sediment supply describes a Major change in sediment supply with additional fine-grained sediments passing out of Cougar downstream into the McKenzie River. Increased fine-grained sediment supply is due to deeper drafts that may pass fine-grained sediment out of Cougar Reservoir. Blue River Reservoir would have a potential for a Moderate change in fine-grained sediment supply. Increased fine-grained sediment supply is due to deeper drafts in Blue River increasing the potential for bank erosion and sloughing generating sediment in the reservoir that may pass the dam due to a concurrent reduction in reservoir storage volume.

**HABS**

Please refer to River Mechanics and Geomorphology Section 3.3.2.5. Alternative 2B would have a Major change at Cougar and Negligible at Blue River in the potential for head-of-reservoir sediment mobilization relative to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Cougar and Blue River dams. Sediment Re-Entrainment and Bank Failure Potential metric would have a Major change for

Cougar and Blue River dams. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Cougar and Blue River. Please refer to River Mechanics and Geomorphology Section 3.3.2.5 for the qualitative analysis of Alternative 2B as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Cougar and Blue River dams. Currently the amount or levels of mercury in Cougar and Blue River is unknown. As there is Major change in shoreline exposure at Cougar and Blue River dams there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.5.4 Middle Fork Willamette Dams*

**Water Temperature**

Alternative 2B has no water temperature measures for the Middle Fork sub-basin. Lookout Point/Dexter Dams has a Negligible effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5-17).

Results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the Middle Fork Willamette River near Dexter gaging site (DEXO; Appendix D Figure 1-401) in the 2011-year scenario there would be no temperature difference from April to October. In the 2015-year scenario observes a 1-degree increase in May, a water temperature decrease up to 3-degrees is observed from June until September. In the 2016-year scenario most months see no change in water temperatures except for August which decreases by 1 degree as compared to the NAA. For the Average of the three years (2011, 2015, 2016) a water temperature decrease by 1 degrees is observed from July through September.

Hills Creek dam would see a Major Adverse effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5-17).

As compared to the NAA the Monthly Mean of Daily Mean water temperatures (deg F) at the Middle Fork Willamette River above Salt Creek gaging site (HCRO; Appendix D Figure 1-402) in the 2011-year scenario there would be no temperature difference from April to October as compared to the NAA. In the 2015-year scenario a decrease up to 2 degrees are observed in May and October, water temperature increases up to 9 degrees in June through September as compared to the NAA. In the 2016-year scenario water temperature decrease is observed up to 4 degrees from May until October, although September would increase by 1 degree. For the Average of the three years (2011, 2015, 2016) a water temperature decrease up to 1 degree is observed in May and October, a temperature increase up to 2-degrees occurs in July through September.

**TDG**

There are no TDG measures for Hills Creek, Lookout Point and Dexter dams although model analysis has determined effects to the sub-basin. Hills Creek, Lookout Point and Dexter dams would have a Negligible effect with Alternative 2B measures (Figure 3.5-57; Table 3.5-18).

Under Alternative 2B, Lookout Point has reduction of 0 days and on average 0 days of TDG exceedance for the year (Appendix D Figure 2-35). Dexter dam TDG is reduced by 0 days and exceeds TDG by 20 days as compared to the average number of days (Appendix D Figure 2-36). Hills Creek dam has a reduction of 0 days of Annual Difference in Number of Days above 110% and on average number of days exceeds TDG by 18 days as compared to the No Action Alternative. The Average Number of Days of Spill per year at Hills Creek is 129 days, Lookout Point is 50 days, and Dexter is 88 days (Appendix D Figure 2-34).

TDG exceedance may occur if water is released through the non-turbine outlets of dams, spill and maintenance operations.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.5 for Alternative 2B. There is a Moderate change in sediment supply with additional fine-grained sediments passing out of Hills Creek into the Middle Fork Willamette above Lookout Point. Increased fine-grained sediment supply is due deeper drafts that may pass fine-grained sediment out of Hills Creek Reservoir and deposit within Lookout Point Reservoir. Dexter Reservoir would have a potential for a Minor change in fine-grained sediment supply. Downstream of Dexter Dam there would be a Negligible potential for change in sediment supply”.

**HABS**

Please refer to River Mechanics and Geomorphology Section 3.3.2.5. Alternative 2B has Negligible change in the potential for head-of-reservoir sediment mobilization relative to the NAA due to changes in operations at Hills Creek, Lookout Point and Fall Creek dams. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Hills Creek and Lookout Point. Fall Creek Reservoir would see a Negligible change. Sediment Re-Entrainment and Bank Failure Potential metric would have a Major change for Hills Creek, Minor change for Lookout Point, Negligible change for Fall Creek Reservoir. Dexter Reservoir is a run-of river project that operates in a small range of pool elevations and is not included in these metrics.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Hills Creek, Lookout Point and Fall Creek. Please refer River Mechanics and Geomorphology Section 3.3.2.5 for the qualitative analysis of Alternative 2B as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Hills Creek and Lookout Point. Fall Creek reservoir would see a Negligible change. Dexter reservoir is a run-of river project that operates in a small range of pool elevations and is not included in this metric. Currently the amount or levels of mercury in Hills Creek, Lookout Point, and Fall Creek is unknown. As there would be a Major change in shoreline exposure at Hills Creek and Lookout Point dams there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.5.5 Coast Fork Dams and Long Tom*

**Water Temperature**

There are no measures at Cottage Grove, Dorena and Fern Ridge dams under Alternative 2B, water temperatures would remain as described in the No Action Alternative and Affected Environment.

**TDG**

There are no measures at Cottage Grove, Dorena and Fern Ridge dams under Alternative 2B, TDG would remain unchanged and similar to the No Action Alternative and Water Quality Affected Environment. TDG exceedance may occur if water is released through the non-turbine outlets of dams, spill and maintenance operations.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.5 Potential for changes in sediment supply section there is Negligible potential for changes in sediment supply relative to the No Action Alternative in the Coast Fork of the Willamette River and Row River free-flowing reaches and Long Tom free-flowing reach.

**HABS**

Please refer to River Mechanics and Geomorphology Section 3.3.2.5 and Technical Appendix C. Alternative 2B has Negligible change in the potential for head-of-reservoir sediment mobilization relative to the NAA due to changes in operations at Detroit Reservoir. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Negligible change for Cottage Grove, Dorena, and Fern Ridge Reservoirs. Sediment Re-Entrainment and Bank Failure Potential metric would have a Negligible change for Cottage Grove, Dorena, and

Fern Ridge reservoirs. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Cottage Grove, Dorena, and Fern Ridge dams. However, referencing River Mechanics and Geomorphology Section 3.3.2.5, Alternative 2B has a Negligible change in shoreline exposure relative to the NAA for Cottage Grove, Dorena, and Fern Ridge Dams. Mercury has been studied in Cottage Grove and Dorena dams as Total Mercury (inorganic) and Methylated Mercury (organic) in sediment Ambers et al. 2001; Eckley et al. 2015; Eckley et al. 2017).

*3.5.2.5.6 Mainstem Willamette River*

**Water Temperature**

Alternative 2B water temperature results for the Mainstem Willamette River at Salem (SLMO;) results in a Negligible effect for Days below 18 C (64.4 F) (Summer). Results are not reported for "Days Near Temperature Target from April through August" or "Days Near Temperature Target from September through March" because there are no temperature targets (Figure 3.5-57; Table 3.5-17)).

Mainstem Willamette River results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the Willamette River near Salem gaging site (SLMO; Appendix D Figure 1-390) in the 2011-year scenario there would be a 1-degree water temperature increase in August. In the 2015-year scenario water temperatures decrease by 2-degree from July through September. In the 2016-year scenario a water temperature increase of 1 degree is observed in May. For the Average of the three years (2011, 2015, 2016) water temperature increases 1-degree in May and then decreases by 1 degree in July.

Alternative 2B water temperature results for the Mainstem Willamette River at Albany (ALBO) results in a Negligible effect for Days below 18 C (64.4 F) (Summer). Results are not reported for "Days Near Temperature Target from April through August" or "Days Near Temperature Target from September through March" because there are no temperature targets (Figure 3.5-57; Table 3.5-17).

Mainstem Willamette River results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the Willamette River at Albany gaging site (ALBO; Appendix D Figure 1-390) in the 2011-year scenario a water temperature increase up to 1 degree is observed in August. In the 2015-year scenario a water temperature decreases by 2-degrees from June through August. In the 2016-year scenario a water temperature increase of 1-degree is observed in May. For the Average of the three years (2011, 2015, 2016) no temperature change is observed.

**TDG**

To the USACE knowledge, there are no TDG gages located on the Willamette River and TDG is presume not to be an issue, as this is a water quality parameter most affected by dam operations. Therefore, TDG gages are typically located downstream of WVS projects where there are known issues.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to the River Mechanics and Geomorphology Section 3.3.2.5.2 and Technical Appendix C (Table 4-14) which states there is Negligible potential for changes in sediment supply relative to the No Action Alternative in the Middle Willamette free-flowing reach.

**HABs**

To the USACE knowledge, there are no OHA HAB advisories near Albany and Salem in public records. At this time the USACE cannot control cyanobacteria bloom formation and growth. Further research is needed to determine factors that assist in toxin production and toxin suppression.

*3.5.2.5.7 Climate Change*

Please reference Technical Appendices B and F for Climate Change qualitative effects. Compared to NAA, Alternative 2B would potentially have more resiliency against climate change effects on water temperature and TDG (increased water temperature control) below Detroit as a result of the proposed SWS and TDG abatement measures at each location. Parameters such as Turbidity and Mercury will likely experience similar effects as those described under NAA. Increased releases from the lake surface via the proposed SWS at Detroit combined with reduced late summer flow volumes under Alternative 2B could lead to increased phytoplankton (algae) compared to NAA (Technical Appendix B Hydrology and Hydraulics).

*3.5.2.5.8 Evaluation of Near-Term Operations Measure*

See Alternative 2A, Section 3.5.2.4, for description of effects due to the Near-Term Operations Measure.

**Table 3.5-16. Summary of Effects of Alternative 2B as compared to the NAA**

| Subbasin | Alternative 2B |
|---|---|
| North Santiam | Big Cliff observes a negligible to beneficial effect for water temperatures with the inclusion of a Water Temperature Control tower at Detroit dam. A beneficial effect to TDG levels is observed at Detroit and Big Cliff. |

| Subbasin | Alternative 2B |
|---|---|
| South Santiam | Foster observes negligible to beneficial effects to downstream water temperatures. Adverse effects to TDG levels are observed at Green Peter and Foster. |
| McKenzie | Cougar would have negligible to beneficial effects to water temperature as Cougar has a Water Temperature Control Tower and provides water temperature control to the McKenzie. Blue River is low priority for water temperature control. A beneficial effect to TDG is observed at Cougar. Blue River is not expected to change as the RO's are utilized and TDG levels would not be expected to change. |
| Middle Fork Willamette | Hills Creek downstream water temperatures would observe an adverse to negligible effect. Dexter downstream water temperatures would observe negligible effects to downstream water temperatures. Fall Creek temperatures would remain as described in the NAA. A negligible effect is observed when including structural improvements for TDG at Hills Creek, Lookout Point, and Dexter dams. |
| Coast Fork Willamette & Long Tom | There are no water temperature measures considered at Cottage Grove, Dorena, and Fern Ridge therefore conditions would remain similar to the NAA. There are no measures considered for TDG management therefore conditions would remain similar to the NAA. |
| Mainstem Willamette | Albany and Salem water temperatures observe negligible effects as compared to the NAA. TDG gages are not located on the Willamette River as TDG concerns are typically located downstream of WVS dams. |

*3.5.2.5.9 Summary of Effects*

Below is provided a summary of Alternative 2B's overall water quality effects.

**Water Temperature**

Alternative 2B structural improvements for water temperature measures include: Water temperature control tower at Detroit Reservoir; Use the RO's to discharge colder water during fall and winter drawdown operations at Green Peter Reservoir; Use of the spillway for surface spill in the summer at Green Peter Reservoir. Modifying existing outlets to allow releases at varying depths for temperature control specifically at Foster Reservoir through a Facility Warm Water Supply (FWWS) pipe and fish weirs. Monthly Mean of Daily Mean Water Temperature difference from the NAA to Alternative 2B can be found in Appendix D Figure 1-396.

**Table 3.5-17. 3-year Average temperature difference with Effects Criteria of Alternative 2B as compared to NAA.**

| Location | Difference from NAA in Days Below 18C each year | Days Below 18C Effects Criteria | Annual Average Number of Days within 2 degrees F of Temperature Target (Apr-Aug) | Days Near Target (Apr-Aug) Effects Criteria | Annual Average Number of Days within 2 degrees F of Temperature Target (Sep-Mar) | Days Near Target (Sep-Mar) Effects Criteria |
|---|---|---|---|---|---|---|
| HCRO | -21 | Major Adverse | -6 | Negligible | 1 | Negligible |
| DEXO | 4 | Negligible | 6 | Negligible | 4 | Negligible |
| CGRO | 0 | Negligible | 10 | Minor Benefit | 16 | Minor Benefit |
| SSFO | 3 | Negligible | 31 | Moderate Benefit | 18 | Minor Benefit |
| BCLO | 0 | Negligible | 42 | Moderate Benefit | 57 | Major Benefit |
| ALBO | 0 | Negligible | NA | | NA | |
| SLMO | -2 | Negligible | NA | | NA | |

Please refer to Technical Appendix D for all Temperature model results by Alternative

NA is due to no temperature targets for the Willamette during this period

<u>**TDG**</u>

Under Alternative 2B there are no measures to reduce TDG. A Major Adverse effect is observed at Green Peter Reservoir and a Moderate Adverse effect is observed at Foster Reservoir. Detroit and Big Cliff dams would potentially have a Moderate Benefit. A Minor Beneficial effect would be observed at Cougar Reservoir. A Negligible effect would be observed at Hills Creek, Lookout Point, and Dexter dams (Figure 3.5-57; Table 3.5-18)).

**Table 3.5-18. Compilation of TDG model results (Appendix D, Figures 2-35;2-36;2-34; Figure 3.5-57) downstream of the dams for Alternative 2B.**

| Location | Average Number of Days Above 110% TDG | Annual Difference in Number of Days Above 110 % TDG compared to the No Action Alternative | Average Number of Days with Spill Per Year | Magnitude of Effects |
|---|---|---|---|---|
| DEX | 20 | 0 | 88 | Negligible |
| LOP | 0 | 0 | 50 | Negligible |
| HCR | 18 | 0 | 129 | Negligible |

| Location | Average Number of Days Above 110% TDG | Annual Difference in Number of Days Above 110 % TDG compared to the No Action Alternative | Average Number of Days with Spill Per Year | Magnitude of Effects |
|---|---|---|---|---|
| CGR | 27 | -30 | 46 | Minor Benefit |
| FOS | 126 | 94 | 284 | Moderate Adverse |
| GPR | 151 | 139 | 190 | Major Adverse |
| BCL | 80 | -69 | 87 | Moderate Benefit |
| DET | 39 | -77 | 62 | Moderate Benefit |

**Turbidity**

There are no measures for Turbidity however sites are qualitatively described in the below sections. Potential Changes in Sediment Supply within the River Mechanics and Geomorphology Section 3.3 and Technical Appendix C is utilized for comparison.

**HABs**

There are no measures for Harmful Algae Blooms however sites are qualitatively described in the below sections. River Mechanics and Geomorphology analysis of Head-of-Reservoir, Shoreline Exposure and Sediment Re-Entrainment and Bank Failure Potential within Section 3.3 and Technical Appendix C of is utilized for comparison.

**Mercury**

There are no WVS EIS Alternative measures for Mercury however sites are qualitatively described in the below sections. Shoreline Exposure analysis within the River Mechanics and Geomorphology Section 3.3 and Technical Appendix C is utilized.

### *3.5.2.6 Alternative 3A – Operations-Focused Fish Passage Alternative*

This section describes the Alternative 3A effects to water quality.

#### *3.5.2.6.1 North Santiam Dam*

**Water Temperature**

Water temperature measures under Alternative 3A include Detroit Reservoir utilizing the RO's to discharge colder water during drawdown operations in the fall and winter to reduce downstream water temperatures. The Detroit spillway would be utilized for surface spill in the summer which would assist in blending water temperatures below in Big Cliff. The lower RO's would be lined to limit cavitation effects and assist in releasing cooler water in the late fall at Detroit Reservoir.

Big Cliff/ Detroit Dams would have a Major Adverse effect of days below 18C (Summer), Moderate Adverse effect for Days Near Temperature Target from April through August, and Minor Benefit for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5-20).

Alternative 3A as compared to the NAA the Monthly Mean of Daily Mean water temperatures at the North Santiam at Niagara gaging site (BCLO; Appendix D Figure 1-405) the 2011-year scenario indicates an increase in water temperatures up to 7-degrees from August through October. Monthly Mean of Daily Max, Water Temperature difference from NAA (Alt3A-NAA). In the 2015-year scenario water temperatures increase up to 10 degrees from April until September, a 1-degree temperature decrease occurs in October. In the 2016-year scenario a water temperature increase up to 15-degrees is observed from May until October as compared to the NAA. For the average of the three years water temperatures increase up to 9-degrees from May until October.

**TDG**

Under Alternative 3A, both Detroit and Big Cliff have a Major Adverse effect as there are no TDG management measures (Figure 3.5-57; Table 3.5-21).

Under Alternative 3A, the average number of days above 110% TDG levels at Big Cliff is 312 and Detroit is 307. Observing the Annual difference in number of days above 110% of TDG exceedances Big Cliff has an increase of 164 days and Detroit is increased by 192 days as compared to the No Action Alternative. The Average Number of Days of Spill per year at Big Cliff is 147 days and Detroit is 249. The adverse effects are likely due to an increase of average number of days with spill per year.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.6, Alternative 3A which states the potential for changes in sediment supply for the North Santiam are described as having a Major change in sediment supply with additional fine-grained sediments passing into Big Cliff run-of-river reservoir. Increased fine-grained sediment supply is due deeper drafts in Detroit reservoir. There is potential for a Moderate change in fine-grained sediment supply to the North Fork Santiam River downstream of Big Cliff dam.

**HABs**

Please refer to River Mechanics and Geomorphology Section 3.3.2.6. Alternative 3A would have Major change in the potential for head-of-reservoir sediment mobilization relative to the NAA due to changes in operations at Detroit Reservoir. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Detroit Reservoir. Sediment Re-Entrainment and Bank Failure Potential metric would have a Major change for Detroit

Reservoir. Big Cliff Reservoir is a run-of river project that operates in a small range of pool elevations and is not included for these metrics. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Detroit. Big Cliff reservoir is a run-of river project that operates in a small range of pool elevations and is not included for this metric. Please refer River Mechanics and Geomorphology Section 3.3.2.6 for the qualitative analysis of Alternative 3A as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Detroit dam. Currently the amount or levels of mercury in Detroit is unknown. As there is Major change in shoreline exposure at Detroit dam there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.6.2 South Santiam Dams*

**Water Temperature**

Water temperature measures under Alternative 3A include Green Peter utilizing the RO's to discharge colder water during drawdown operations in the fall and winter to reduce downstream water temperatures and volitional downstream fish passage. The Green Peter and Foster dam spillways would be utilized in the summer for surface spill.

Green Peter/Foster Dams would see a Negligible effect for Days below 18 C (64.4 F) (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Minor Benefit for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5-20).

Alternative 3A results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the South Santiam River near Foster gaging site (SSFO; Appendix D Figure 1-406) the 2011-year scenario would see a water temperature increase starting in May through October up to 8 degrees, although July has no temperature change as compared to the NAA. In the 2015-year scenario water temperatures increase from 1 to 4 degrees in April through June, a decrease in temperatures from 4 to 13 degrees is observed from July to September. In the 2016-year scenario water temperatures increase up to 7 degrees from May to August and then decrease by 1 degree in September and October. For the Average of the three years (2011, 2015, 2016) an increase 1 to 4 degrees from May through June and then decrease up to 2 degrees from August and September.

**TDG**

Under Alternative 3A, both Green Peter and Foster Reservoir would have an Adverse effect as there are no TDG management measures. Green Peter would have a Major Adverse effect and Foster would have a Moderate Adverse effect (Figure 3.5-57; Table 3.5-21).

Under Alternative 3A, the average number of days above 110% TDG levels at Green Peter is 151 days and Foster is 127 days. Observing the Annual difference in number of days above 110% of TDG exceedances Green Peter has an increase of 139 days and Foster is 95 days as compared to the No Action Alternative. The Average Number of Days of Spill per year at Green Peter is 189 days and Foster is 220 days. The adverse effects are likely due to an increase of average number of days with spill per year.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.6. Potential for changes in sediment supply for the South Santiam there is a Major change in sediment supply with additional fine-grained sediments passing into Foster Reservoir as compared to the NAA. Increased fine-grained sediment supply is due deeper drafts in Green Peter Reservoir that have the potential to pass sediment through Green Peter Dam and partially through the Foster Reservoir. There is potential for a Moderate change in fine-grained sediment supply to the South Fork Santiam River downstream of Foster dam. Increased suspended sediments may cause an elevation in turbidity levels during drawdown operations or precipitation events.

**HABs**

Please refer to River Mechanics and Geomorphology Section 3.3.2.6. Alternative 3A has Major change at Green Peter and Minor change at Foster in the potential for head-of-reservoir sediment mobilization relative to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Green Peter Reservoir and Negligible for Foster Reservoir. Sediment Re-Entrainment and Bank Failure Potential metric would have a Major change for Green Peter Reservoir and Negligible for Foster Reservoir. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Green Peter and Foster. Please refer River Mechanics and Geomorphology Section 3.3.2.6 for the qualitative analysis of Alternative 3A as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Green Peter reservoir and Negligible for Foster reservoir. Currently the amount or levels of mercury in Green Peter and Foster reservoirs is unknown. As there is Major change in shoreline exposure at Green Peter dam there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

#### *3.5.2.6.3 McKenzie Dams*

**Water Temperature**

Water temperature measures under Alternative 3A include a modification to the spillway at Blue River Reservoir to provide better water temperature management. The spillway would be used in the summer for surface spill. Not a direct water temperature measure but equally as important is Cougar Reservoir implementing spring and fall drawdown operations for volitional downstream fish passage. And Blue River implementing a fall drawdown 15 ft below minimum conservation (1180 ft).

South Fork McKenzie River near Rainbow site (CGRO) is downstream of Blue River and Cougar Dam and would see a Negligible effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Minor Adverse for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5-20).

Temperature results for Alternative 3A effects are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the South Fork McKenzie River near Rainbow gaging site (CGRO; Appendix D Figure 1-407) in the 2011-year scenario there would be a water temperature decrease from 1 to 5-degrees from April through August, a 6-degree water temperature increase would occur in October as compared to the NAA. In the 2015-year scenario a water temperature increase of 1 to 2 degrees is observed in May, August, and September. A temperature decrease of 1-2 degrees is observed in June and July for the 2015-year scenario. In the 2016-year scenario a temperature increase is observed up to 6 degrees from April until July, a temperature decrease of up to 6 degrees occurs from August until October as compared to the NAA. For the Average of the three years (2011, 2015, 2016) a temperature increase up to 7-degrees is observed from April until August, a temperature decrease of 3-4 degrees occurs in September and October as compared to the NAA.

**TDG**

There are no TDG measures under Alternative 3A for Cougar Reservoir. Cougar Reservoir would have a Negligible with Alternative 3A measures (Figure 3.5-57; Table 3.5-21).

Under Alternative 3A, the average number of days above 110% TDG levels at Cougar is 77 days. Observing the Annual difference in number of days above 110% of TDG exceedance Cougar is 20 days as compared to the No Action Alternative. The Average Number of Days of Spill per year at Cougar is 240 days.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to Section 3.3.2.6 River Mechanics and Geomorphology Potential Changes in Sediment Supply for Alternative 3A there is a Moderate change in sediment supply with additional fine-grained sediments passing out of

Cougar downstream into the McKenzie River. Increased fine-grained sediment supply is due to deeper drafts that may pass fine-grained sediment out of Cougar Reservoir. Blue River Reservoir would have a potential for a Moderate change in fine-grained sediment supply as compared to the NAA. Increased fine-grained sediment supply is due to deeper drafts in Blue River Cougar Reservoir would implement a spring and fall drawdown, while Blue River would implement a fall drawdown.

**HABs**

Please refer to River Mechanics and Geomorphology Section 3.3.2.6. Alternative 3A has Major change at Cougar and Minor change at Blue River in the potential for head-of-reservoir sediment mobilization relative to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Cougar and Blue River dams. Sediment Re-Entrainment and Bank Failure Potential metric would have a Moderate change for Cougar and Blue River dams. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Cougar and Blue River. Please refer River Mechanics and Geomorphology Section 3.3.2.6 for the qualitative analysis of Alternative 3A as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Cougar and Blue River dams. The Shoreline Exposure metric was developed as a surrogate for shoreline erosion processes and is a result of operational change. Currently the amount or levels of mercury in Cougar and Blue River is unknown. As there is Major change in shoreline exposure at Cougar and Blue River dams there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.6.4 Middle Fork Willamette Dams*

**Water Temperature**

Water temperature measures under Alternative 3A include Hills Creek Reservoir modification to the spillway and use the spillway for surface spill in the summer. Lookout point Reservoir would utilize the RO’s to discharge colder water during drawdown operations in fall and winter to reduce downstream water temperatures. The Lookout Point spillway would be utilized in the summer for surface spill. Dexter spillway would be utilized in order to spread surface spill.

Lookout Point/Dexter Dams would see a Major Adverse effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5-20)).

Water temperature results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the Middle Fork Willamette River near Dexter gaging site (DEXO; Appendix D Figure 1-408) in the 2011-year scenario water temperature increase from 1 to 6 degrees is observed from April to September. In the 2015-year scenario observes a 1-3 degree increase from April through July, then decrease of 1 degree in September. In the 2016-year scenario a 2 to 6-degree water temperature increase is observed from April through August and decrease by 1 degree in October as compared to the NAA. For the Average of the three years (2011, 2015, 2016) a water temperature increases from 1-4 degrees in April through September and decreases by one degree in October.

Hills Creek dam would see a Major Adverse for Days below 18 C (64.4 F) (Summer), Major Benefit for Days Near Temperature Target from April through August, and Minor Benefit for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5-20).

As compared to the NAA the Monthly Mean of Daily Mean water temperatures at the Middle Fork Willamette River above Salt Creek gaging site (HCRO; Appendix D Figure 1-409) in the 2011-year scenario water temperature increase from 2 to 11 degrees is observed from April to August, a decrease from 4 to 6 degrees occurs in September and October. In the 2015-year scenario observes a 1-6 degree increase from April through July, then decrease of 1 degree in October as compared to the NAA. In the 2016-year scenario water temperature increase 3-6 degrees from April through July and decrease up to 6 degrees from August to October as compared to the NAA. For the Average of the three years (2011, 2015, 2016) a water temperature increase 2 to 7 degrees from April through August and then decrease up to 4 degrees in September and October.

**TDG**

Under Alternative 3A, there are no TDG measures at Lookout Point and Dexter dams. Lookout Point and Hills Creek would have a Negligible effect and Dexter Reservoir would have a Minor Adverse effect with Alternative 3A measures (Figure 3.5-57; Table 3.5-21).

Under Alternative 3A, the average number of days above 110% TDG levels at Hills Creek is 13 days, Lookout Point is 0 days, and Dexter is 53 days (Appendix D Figure 2-35). Observing the Annual difference in number of days above 110% of TDG exceedances Hills Creek is decreased by 6 days, Lookout Point is 0 days, and Dexter is increased to 33 days as compared to the No Action Alternative (Appendix D Figure 2-36). The Average Number of Days of Spill per year at Hills Creek is 82 days, Lookout Point is 225 days, and Dexter is 146 days (Appendix D Figure 2-34). The adverse effects are likely due to an increase of average number of days with spill per year.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. In River Mechanics and Geomorphology Section 3.3.2.6 for Alternative 3A the potential for changes in sediment supply for the Middle Fork Willamette is stated as having a Major change in sediment supply into Dexter Reservoir with additional fine-grained sediments passing out of Lookout Point run-of-river reservoir. Increased fine-grained sediment supply is due deeper drafts that may pass fine-grained sediment out of Lookout Point Reservoir decreasing trap efficiency and increasing the potential for bank erosion and sloughing. There is a potential for a Moderate change in sediment supply with additional fine-grained sediment passing into the Middle Fork of the Willamette below Dexter dam.

**HABs**

Please refer to River Mechanics and Geomorphology Section 3.3.2.6. Alternative 3A has potential for Minor changes at Hills Creek, Major changes at Lookout Point, Negligible changes at Fall Creek dams for head-of-reservoir sediment mobilization relative to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Minor change for Hills Creek, Major change for Lookout Point, and Negligible change for Fall Creek Reservoirs. Sediment Re-Entrainment and Bank Failure Potential metric would have a Negligible change for Hills Creek, Major change for Lookout Point, and Negligible change for Fall Creek Reservoirs. Dexter Reservoir is a run-of river project that operates in a small range of pool elevations and is not included in these metrics. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Hills Creek, Lookout Point and Fall Creek. Please refer River Mechanics and Geomorphology Section 3.3.2.6 for the qualitative analysis of Alternative 3A as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Minor change for Hills Creek, Major change for Lookout Point. Fall Creek reservoir would see a Negligible change. Dexter reservoir is a run-of river project that operates in a small range of pool elevations and is not included in this metric. Currently the amount or levels of mercury in Hills Creek, Lookout Point, and Fall Creek is unknown. As there would be changes in shoreline exposure at Hills Creek and Lookout Point dams there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.6.5 Coast Fork Dams and Long Tom*

**Water Temperature**

There are no measures at Cottage Grove, Dorena and Fern Ridge dams under Alternative 3a, water temperatures would remain as described in the No Action Alternative and Water Quality Affected Environment.

**TDG**

There are no TDG measures at Cottage Grove, Dorena and Fern Ridge dams under Alternative 3A, TDG would remain unchanged and similar to the No Action Alternative and Water Quality Affected Environment. TDG exceedance may occur if water is released through the non-turbine outlets of dams, spill and maintenance operations.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to Section 3.3.2.6 River Mechanics and Geomorphology, Potential for changes in sediment supply section, which states there is a Moderate change in sediment supply with additional fine-grained sediments passing into the Coast Fork Willamette and Row River from Cottage Grove and Dorena dams. Increased fine-grained sediment supply is due deeper drafts in Cottage Grove and Dorena dams that have potential to induce bank erosion and sloughing generating sediment that may pass the dam to a concurrent reduction in reservoir storage volume. There is Negligible change in sediment supply relative to the NAA in the Long Tom River.

**HABs**

Please refer to River Mechanics and Geomorphology Section 3.3.2.6. Alternative 3A has Negligible change in the potential for head-of-reservoir sediment mobilization relative to the NAA due to changes in operations at Cottage Grove, Dorena, and Fern Ridge dams. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Cottage Grove and Dorena Reservoirs. Fern Ridge Reservoir results in a Negligible change. Sediment Re-Entrainment and Bank Failure Potential metric would have a Moderate change for Cottage Grove and Dorena Reservoirs. Fern Ridge Reservoir results in a Negligible change. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Cottage Grove, Dorena, and Fern Ridge dams. However, referencing River Mechanics and Geomorphology Section 3.3.2.6 Alternative 3A would have a Major change in shoreline exposure relative to the NAA for Cottage Grove and Dorena Dams. Fern Ridge Reservoir would have a Negligible change. Mercury has been studied in Cottage Grove and Dorena Dams as Total Mercury (inorganic) and Methylated Mercury (organic) in sediment Ambers et al. 2001; Eckley et al. 2015; Eckley et al. 2017).

#### *3.5.2.6.6 Mainstem Willamette River*

**Water Temperature**

Alternative 3A water temperature results for the Mainstem Willamette River at Salem (SLMO) results in a Minor Adverse effect for Days below 18 C (64.4 F) (Summer). Results are not reported for “Days Near Temperature Target from April through August” or “Days Near Temperature Target from September through March” because there are no temperature targets (Figure 3.5-57; Table 3.5-20).

Mainstem Willamette River Alternative 3A results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the Willamette River near Salem gaging site (SLMO; Figure 1-384) 2011-year scenario water temperature increases by 1 degree from June through September as compared to the NAA. In the 2015-year scenario temperature increases 1 to 2 degrees in April through June and then decreases by 1 degree in July and August as compared to the NAA. In the 2016-year scenario water temperatures increase up to 2-degrees from May until August as compared to the NAA. For the average of the three years (2011,2015, 2016) water temperature increases up to 2 degrees from May until July as compared to the NAA.

Alternative 3A water temperature results for the Mainstem Willamette River at Albany (ALBO) results in a Minor Adverse effect for Days below 18 C (64.4 F) (Summer). Results are not reported for “Days Near Temperature Target from April through August” or “Days Near Temperature Target from September through March” because there are no temperature targets (Figure 3.5-57; Table 3.5-20).

Mainstem Willamette River results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the Willamette River at Albany gaging site (ALBO; Figure 1-384) in the 2011-year scenario water temperatures increase up to 2 degrees from June through September as compared to the NAA. In the 2015-year scenario water temperatures increase up to 2-degrees in May and June as compared to the NAA. In the 2016-year scenario water temperatures increase up to 2-degrees from May until August as compared to the NAA. For the average of the three years (2011,2015, 2016) water temperatures increase up to 2-degrees from May until August as compared to the NAA.

**TDG**

To the USACE knowledge, there are no TDG gages located on the Willamette River and TDG is presume not to be an issue, as this is a water quality parameter most affected by dam operations. Therefore, TDG gages are typically located downstream of WVS projects where there are known issues.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and

Geomorphology Section 3.3.2.6 and Technical Appendix C Potential for changes in sediment supply "there is Negligible potential for changes in sediment supply relative to the No Action Alternative in the Middle Willamette free-flowing reach".

**<u>HABs</u>**

To the USACE knowledge, there have been no OHA advisories near Albany and Salem. At this time the USACE cannot control cyanobacteria bloom formation and growth. Further research is needed to determine factors that assist in toxin production and toxin suppression.

*3.5.2.6.7 Climate Change*

Please reference Technical Appendices B and F for Climate Change qualitative effects. Compared to NAA, Alternative 3B would potentially have less resiliency against climate change effects on water temperature (decreased water temperature control) below Detroit, Hills Creek, and Lookout Point, and lower on the mainstem Willamette at Salem as a result of the lower storage and outflows at each location. However, Alternative 3B would potentially have more resiliency against climate change effects on water temperature (more normative water temperature) below Green Peter-Foster due to the elevation of the summer lake levels at that project. TDG will likely have more resiliency against climate change effects below Lookout Point-Dexter due to the reduced reservoir storage and expected hydrologic effects shown in Technical Appendix B (Hydrology and Hydraulics). Parameters such as Turbidity, HABs, and Mercury will likely experience similar effects as those described under NAA.

*3.5.2.6.8 Evaluation of Near-Term Operations Measure*

See Alternative 2A, Section 3.5.2.4, for description of effects due to the Near-Term Operations Measure.

**Table 3.5-19. Summary of Effects of Alternative 3A as compared to the NAA**

| Subbasin | Alternative 3A |
|---|---|
| North Santiam | Big Cliff has adverse effects for days near 18C (64.4F) summer. Beneficial effects are observed for days near temperature targets from April through August and September through March. Adverse effects to TDG levels are observed at Detroit and Big Cliff. |
| South Santiam | Foster observes negligible to beneficial effects to downstream water temperatures. Adverse effects to TDG levels are observed at Green Peter and Foster. |
| McKenzie | Cougar would have negligible to adverse effects to water temperature as Cougar has a Water Temperature Control Tower and provides water temperature control to the McKenzie. A negligible effect to TDG is observed at Cougar. Blue River is not expected to change as the RO's are utilized and TDG levels would not be expected to change. |

| Subbasin | Alternative 3A |
|---|---|
| Middle Fork Willamette | Hills Creek downstream water temperatures would observe an adverse to negligible effect. Dexter downstream water temperatures would observe beneficial to adverse effects to downstream water temperatures. Fall Creek temperatures would remain as described in the NAA. A negligible effect is observed at Hills Creek and Lookout Point. Dexter dam observes adverse effects to TDG. |
| Coast Fork Willamette & Long Tom | There are no water temperature measures considered at Cottage Grove, Dorena, and Fern Ridge therefore conditions would remain similar to the NAA. There are no measures considered for TDG management therefore conditions would remain similar to the NAA. |
| Mainstem Willamette | Albany and Salem water temperatures observe adverse effects as compared to the NAA. TDG gages are not located on the Willamette River as TDG concerns are typically located downstream of WVS dams. |

*Summary of effects*

Below is provided a summary of Alternative 3A's overall water quality effects.

**Water Temperature**

Alternative 3A would utilize operation-based measures for fish passage survivability within the WVS dams and compared to the NAA. Operational improvements for water temperature measures include: Utilizing the RO's to discharge cold water during drawdown operations in the fall and winter to reduce water temperatures below Detroit, Green Peter, and Lookout Point dams; Utilizing the spillway for surface spill in the summer at Detroit, Green Peter, Foster, Blue River, Hills Creek, and Lookout point dams. Spreading spill would be conducted at Dexter and Lookout Point. Modify existing outlets to allow releases at varying depths for temperature control by modifying the spillway to allow releases at varying depths for temperature control at Blue River and Hills Creek dams; Lining of the lower RO tunnels to limit cavitation effects and to assist in temperature control at Detroit dam. Monthly Mean of Daily Mean Water Temperature difference from NAA to Alternative 3A can be found in Appendix D Figure 1-404.

**Table 3.5-20. 3-year Average temperature difference with Effects Criteria of Alternative 3a as compared to NAA.**

| Location | Difference from NAA in Days Below 18C each year | Days Below 18C Effects Criteria | Annual Average Number of Days within 2 degrees F of Temperature Target (Apr-Aug) | Days Near Target (Apr-Aug) Effects Criteria | Annual Average Number of Days within 2 degrees F of Temperature Target (Sep-Mar) | Days Near Target (Sep-Mar) Effects Criteria |
|---|---|---|---|---|---|---|
| HCRO | -16 | Major Adverse | 56 | Major Benefit | 16 | Minor Benefit |
| DEXO | -30 | Major Adverse | 2 | Negligible | 4 | Negligible |
| CGRO | 0 | Negligible | -1 | Negligible | -12 | Minor Adverse |
| SSFO | 3 | Negligible | 40 | Moderate Benefit | 18 | Minor Benefit |
| BCLO | -43 | Major Adverse | -24 | Moderate Adverse | 10 | Minor Benefit |
| ALBO | -9 | Minor Adverse | NA | | NA | |
| SLMO | -7 | Minor Adverse | NA | | NA | |

Please refer to Technical Appendix D for all Temperature model results by Alternative.
NA is due to no temperature targets for the Willamette during this period

**TDG**

A summary of Alternative 3A includes no measures for TDG abatement at the WVS dams. A potential Major Adverse effect would be observed at Detroit, Big Cliff, and Green Peter dams. A Moderate Adverse effect would be observed at Foster Reservoir. A potential Minor Adverse effect would be observed at Dexter Reservoir. A potential Negligible effect would be observed at Cougar, Hills Creek, and Lookout Point dams (Figure 3.5-57; Table 3.5-21).

**Table 3.5-21. Compilation of TDG model results (Appendix D Figures 2-35;2-36;2-34; Figure 3.5-57) downstream of the dams for Alternative 3A.**

| Location | Average Number of Days Above 110% TDG | Annual Difference in Number of Days Above 110 % TDG compared to the No Action Alternative | Average Number of Days with Spill Per Year | Magnitude of Effects |
|---|---|---|---|---|
| DEX | 53 | 33 | 146 | Minor Adverse |

| Location | Average Number of Days Above 110% TDG | Annual Difference in Number of Days Above 110 % TDG compared to the No Action Alternative | Average Number of Days with Spill Per Year | Magnitude of Effects |
|---|---|---|---|---|
| LOP | 0 | 0 | 225 | Negligible |
| HCR | 13 | -6 | 82 | Negligible |
| CGR | 77 | 20 | 240 | Negligible |
| FOS | 127 | 95 | 220 | Moderate Adverse |
| GPR | 151 | 139 | 189 | Major Adverse |
| BCL | 312 | 164 | 147 | Major Adverse |
| DET | 307 | 192 | 249 | Major Adverse |

**Turbidity**

There are no measures for Turbidity however sites are qualitatively described in the below sections. Potential Changes in Sediment Supply within the River Mechanics and Geomorphology Section 3.3 and Technical Appendix C is utilized for comparison.

**HABs**

There are no measures for Harmful Algae Blooms however sites are qualitatively described in the below sections. River Mechanics and Geomorphology analysis of Head-of-Reservoir, Shoreline Exposure and Sediment Re-Entrainment and Bank Failure Potential within Section 3.3 and Technical Appendix C is utilized for comparison.

**Mercury**

There are no WVS EIS Alternative measures for Mercury however sites are qualitatively described in the below sections. Shoreline Exposure analysis within the River Mechanics and Geomorphology Section 3.3 and Technical Appendix C is utilized.

### *3.5.2.7 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at Cougar*

This section describes the Alternative 3B effects to water quality.

#### *3.5.2.7.1 North Santiam Dam*

**Water Temperature**

Water temperature measures under Alternative 3B include Detroit Reservoir utilizing the RO’s to discharge colder water during drawdown operations in the fall and winter to reduce downstream water temperatures. The Detroit spillway would be utilized for surface spill in the summer which would assist in blending water temperatures below in Big Cliff. The lower RO's would be lined to limit cavitation effects and assist in releasing cooler water in the late fall at Detroit Reservoir.

Big Cliff/ Detroit Dams would have a Negligible effect of days below 18C (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5 23).

Alternative 3B as compared to the NAA the Monthly Mean of Daily Mean water temperatures at the North Santiam at Niagara gaging site (BCLO; Appendix D Figure 1-412) the 2011-year scenario indicates an increase in water temperatures up to 4-degrees from May through July, an 8 degree temperature decrease is observed in September as compared to the NAA. Monthly Mean of Daily Max, Water Temperature difference from NAA (Alt3B-NAA). In the 2015-year scenario water temperatures decrease up to 5 degrees from May until October, although a 1-degree temperature increase is observed in August. In the 2016-year scenario a water temperature increase up to 2-degrees is observed in May and June, a temperature decrease of 1 to 2 degrees occurs in July and September. For the average of the three years water temperatures increase by 1-degrees in July, and then decrease up to 5 degrees in September and October as compared to the NAA.

**TDG**

Both Detroit and Big Cliff have a Moderate Adverse effect when including Alternative 3B as there are no TDG abatement measures (Figure 3.5-57; Table 3.5-24).

Under Alternative 3B, the average number of days above 110% TDG levels at Big Cliff is 226 and Detroit is 203 (Appendix D Figure 2-35). Observing the Annual difference in number of days above 110% of TDG exceedances Big Cliff has an increase of 78 days and Detroit is increased by 87 days as compared to the No Action Alternative (Appendix D Figure 2-36). The Average Number of Days of Spill per year at Big Cliff is 125 days and Detroit is 197 (Appendix D Figure 2-34).

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.7 for Potential for changes in sediment supply for the North Santiam section which states "there is a Moderate change in sediment supply with additional fine-grained sediments passing into Big Cliff run-of-river reservoir. Increased fine-grained sediment supply is due deeper drafts in Detroit Reservoir. There is potential for a Minor change in fine-grained sediment supply to the North Fork Santiam River downstream of Big Cliff dam".

**HABs**

Please refer to River Mechanics and Geomorphology Section 3.3.2.7, which states Alternative 3B has Major changes in the potential for head-of-reservoir sediment mobilization relative to the NAA due to changes in operations at Detroit Reservoir. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Detroit Reservoir. Sediment Re-Entrainment and Bank Failure Potential metric would have a Major change for Detroit Reservoir. Big Cliff Reservoir is a run-of-river project that operates in a small range of pool elevations and is not included for these metrics. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Detroit. Big Cliff reservoir is a run-of river project that operates in a small range of pool elevations and is not included for this metric. Please refer River Mechanics and Geomorphology Section 3.3.2.7 for the qualitative analysis of Alternative 3B as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Detroit dam. Currently the amount or levels of mercury in Detroit is unknown. As there is Major change in shoreline exposure at Detroit dam there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.7.2 South Santiam Dams*

**Water Temperature**

Water temperature measures under Alternative 3B include Green Peter utilizing the RO’s to discharge colder water during drawdown operations in the fall and winter to reduce downstream water temperatures and volitional downstream fish passage. The Green Peter and Foster dam spillways would be utilized in the summer for surface spill.

Green Peter/Foster Dams would see a Major Adverse effect for Days below 18 C (64.4 F) (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5 23).

Alternative 3B results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the South Santiam River near Foster gaging site (SSFO; Appendix D Figure 1-413) the 2011-year scenario would see a water temperature increase starting in June through October up to 12 degrees, although July would have a 2-degree temperature decrease as compared to the NAA. In the 2015-year scenario water temperatures increase from 1 to 10 degrees in April through September as compared to the NAA. In the 2016-year scenario water temperatures increase up to 14 degrees from April through September as compared to the NAA. For the Average of the three years (2011, 2015, 2016) an increase 1 to 8 degrees from April through October as compared to the NAA.

**TDG**

There are no TDG abatement measures at Green Peter and Foster. Both Green Peter and Foster dams would have a Minor Adverse effect under Alternative 3B as compared to the NAA (Figure 3.5-57; Table 3.5-24).

Under Alternative 3B, the average number of days above 110% TDG levels at Green Peter is 62 days and Foster is 69 days (Appendix D Figure 2-35). Observing the Annual difference in number of days above 110% of TDG exceedances Green Peter has an increase of 50 days and Foster is 37 days as compared to the No Action Alternative (Appendix D Figure 2-36). The Average Number of Days of Spill per year at Green Peter is 235 days and Foster is 211 days (Appendix D Figure 2-34).

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.7 Potential for changes in sediment supply for the South Santiam "there is Major change in sediment supply with additional fine-grained sediments passing into Foster Reservoir. Increased fine-grained sediment supply is due deeper drafts in Green Peter Reservoir that have the potential to pass sediment through Green Peter Dam and partially through the Foster Reservoir. There is potential for a Moderate change in fine-grained sediment supply to the South Fork Santiam River downstream of Foster dam."

**HABs**

Please refer to River Mechanics and Geomorphology Section 3.3.2.7, which states Alternative 3B would have Major change at Green Peter and Minor change at Foster in the potential for head-of-reservoir sediment mobilization relative to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Green Peter Reservoir and Negligible for Foster Reservoir. Sediment Re-Entrainment and Bank Failure Potential metric would have a Major change for Green Peter Reservoir and Negligible for Foster Reservoir. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Green Peter and Foster. Please refer River Mechanics and Geomorphology Section 3.3.2.7 for the qualitative analysis of Alternative 3B as compared to the NAA. "The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Green Peter reservoir and Negligible for Foster reservoir. Currently the amount or levels of mercury in Green Peter and Foster reservoirs is unknown. As there is Major change in shoreline exposure at Green Peter dam there is potential for an increase for the methylation process to occur with water. Changes in shoreline exposure is a long-term, direct effect.

#### *3.5.2.7.3 McKenzie Dams*

**Water Temperature**

Water temperature measures under Alternative 3B include modifying the diversion tunnel at Cougar Reservoir to provide better temperature control. Measures for Blue River include a modification to the spillway to provide better water temperature management. The Blue River spillway would be used in the summer for surface spill

South Fork McKenzie River near Rainbow site (CGRO) is downstream of Blue River and Cougar Dam and would see a Negligible effect for Days below 18 C (64.4 F) (Summer), Minor Benefit for Days Near Temperature Target from April through August, and Minor Benefit for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5 23)).

Temperature results for Alt 3B effects are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the South Fork McKenzie River near Rainbow gaging site (CGRO; Appendix D Figure 1-414) in the 2011-year scenario there would be a water temperature decrease from 1 to 3-degrees from April through July, a 4-degree water temperature increase would occur in October as compared to the NAA. In the 2015-year scenario a water temperature decrease of 1 to 7 degrees is observed in May through October as compared to the NAA. In the 2016-year scenario a temperature decrease is observed up to 5 degrees from June through October as compared to the NAA. For the Average of the three years (2011, 2015, 2016) a temperature decrease up to 5-degrees is observed from May through October as compared to the NAA.

**TDG**

There are no TDG management measures for Cougar Reservoir although a Minor Beneficial effect is observed with Alternative 3B measures (Figure 3.5-57; Table 3.5-24).

Under Alternative 3B, the average number of days above 110% TDG levels at Cougar is 26 days (Appendix D Figure 2-35). Observing the Annual difference in number of days above 110% of TDG exceedance Cougar is decreased to 31 days as compared to the No Action Alternative (Appendix D Figure 2-36). The Average Number of Days of Spill per year at Cougar is 46 days (Appendix D Figure 2-34).

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.7 Potential Changes in Sediment Supply there is a potential for a Major change in sediment supply with additional fine-grained sediments passing out of Cougar downstream into the McKenzie River. Increased fine-grained sediment supply is due to deeper drafts that may pass fine-grained sediment out of Cougar Reservoir. Blue River Reservoir would have a potential for a Moderate change in fine-grained sediment supply downstream of Blue River dam. Increased fine-grained sediment supply is due to deeper drafts in Blue River".

**HABs**

Please refer to River Mechanics and Geomorphology Section 3.3.2.7, which states Alternative 3B has Major change at Cougar and Minor change at Blue River in the potential for head-of-reservoir sediment mobilization relative to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Cougar and Blue River dams. Sediment Re-Entrainment and Bank Failure Potential metric would have a Major change for Cougar and Moderate change for Blue River dams. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Cougar and Blue River. Please refer River Mechanics and Geomorphology Section 3.3.2.7 for the qualitative analysis of Alternative 3B as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Cougar and Blue River dams. Currently the amount or levels of mercury in Cougar and Blue River is unknown. As there is Major change in shoreline exposure at Cougar and Blue River dams there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

#### *3.5.2.7.4 Middle Fork Willamette Dams*

**Water Temperature**

Water temperature measures under Alternative 3B include Hills Creek Reservoir modification to the spillway and use the spillway for surface spill in the summer. Lookout point Reservoir would utilize the RO's to discharge colder water during drawdown operations in fall and winter to reduce downstream water temperatures. The Lookout Point spillway would be utilized in the summer for surface spill. Dexter spillway would be utilized in order to spread surface spill.

Lookout Point/Dexter Dams would see a Minor Adverse effect for Days below 18 C (64.4 F) (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5-23).

Water temperature results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the Middle Fork Willamette River near Dexter gaging site (DEXO; Appendix D Figure 1-415) in the 2011-year scenario water temperature increase from 1 to 8 degrees is observed from April to August. In the 2015-year scenario observes a 1 degree decrease from June through September as compared to the NAA. In the 2016-year scenario a 2 to 6-degree water temperature increase is observed from April through July and decrease up to 7-degrees from August until October as compared to the NAA. For the Average of the three years (2011, 2015, 2016) a water temperature increases from 1-4 degrees in April through August and decreases up to 3-degrees in September and October.

Hills Creek dam would see a Major Adverse for Days below 18 C (64.4 F) (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5 23).

As compared to the NAA the Monthly Mean of Daily Mean water temperatures (deg F) at the Middle Fork Willamette River above Salt Creek gaging site (HCRO; Appendix D Figure 1-416) in the 2011-year scenario water temperature increase from 1 to 5 degrees is observed from April to October. In the 2015-year scenario observes a 2-9 degree increase from April through September as compared to the NAA. In the 2016-year scenario water temperature increase 3-8 degrees from April through September as compared to the NAA. For the Average of the three years (2011, 2015, 2016) water temperatures increase 2 to 7 degrees from April through September as compared to the NAA.

**TDG**

There are no TDG abatement measures at Lookout Point, Hills Creek and Dexter dams. Lookout Point and Hills Creek would have a Negligible effect and Dexter Reservoir have a Minor Adverse effect with Alternative 3B as compared to the NAA (Figure 3.5-57; Table 3.5-24).

Under Alternative 3B, the average number of days above 110% TDG levels at Hills Creek is 19 days, Lookout Point is 0 days, and Dexter is 62 days (Figure 2-35). Observing the Annual difference in number of days above 110% of TDG exceedances Hills Creek is 0 days, Lookout Point is 0 days, and Dexter is increased to 42 days as compared to the No Action Alternative (Appendix D Figure 2-36). The Average Number of Days of Spill per year at Hills Creek is 89 days, Lookout Point is 196 days, and Dexter is 126 days (Appendix D Figure 2-34).

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.7 Potential for changes in sediment supply for the Middle Fork Willamette "there is a Major change in sediment supply into Dexter Reservoir with additional fine-grained sediments passing out of Lookout Point run-of-river reservoir. Increased fine-grained sediment supply is due deeper drafts that may pass fine-grained sediment out of Lookout Point Reservoir decreasing trap efficiency and increasing the potential for bank erosion and sloughing. There is a potential for a Moderate change in sediment supply with additional fine-grained sediment passing into the Middle Fork of the Willamette below Dexter dam".

**HABs**

Please refer to River Mechanics and Geomorphology Section 3.3.2.7, which states Alternative 3B has a Major change at Hills Creek, Major change at Lookout Point, Negligible changes at Fall Creek dams for head-of-reservoir sediment mobilization relative to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Hills Creek and Lookout Point Reservoirs. Fall Creek reservoir would result in a Negligible change. Sediment Re-Entrainment and Bank Failure Potential metric would have a Negligible change for Hills Creek, Major change for Lookout Point, and Negligible change for Fall Creek Reservoirs. Dexter Reservoir is a run-of river project that operates in a small range of pool elevations and is not included in these metrics. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Hills Creek, Lookout Point and Fall Creek. Please refer to River Mechanics and Geomorphology Section 3.3.2.7 for the qualitative analysis of Alternative 3B as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Hills Creek and Lookout Point Reservoirs. Fall Creek reservoir would result in a Negligible change. Dexter reservoir is a run-of river project that operates in a small range of pool elevations and is not included in this metric. Currently the amount or levels of mercury in Hills Creek, Lookout Point, and Fall Creek is unknown. As there would be changes in shoreline exposure at Hills Creek and Lookout Point dams there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.7.5 Coast Fork Dams And Long Tom*

**Water Temperature**

There are no temperature measures for Cottage Grove, Dorena, Fern Ridge dams under Alternative 3B. Conditions would remain as described in the No Action Alternative and Water Quality Affected Environment.

**TDG**

There are no measures at Cottage Grove, Dorena and Fern Ridge dams under Alternative 3B. TDG would remain unchanged and similar to the No Action Alternative and Water Quality Affected Environment. TDG exceedance may occur if water is released through the non-turbine outlets of dams, spill and maintenance operations.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.7 potential for changes in sediment supply section would have a

Moderate change in sediment supply with additional fine-grained sediments passing into the Coast Fork Willamette and Row River from Cottage Grove and Dorena dams. Increased fine-grained sediment supply is due deeper drafts in Cottage Grove and Dorena dams that have potential to induce bank erosion and sloughing generating sediment with the reduction of reservoir storage volume. There is Negligible change in sediment supply relative to the NAA in the Long Tom River.

**HABs**

Please refer to River Mechanics and Geomorphology Section 3.3.2.7, which states Alternative 3B has Negligible change in the potential for head-of-reservoir sediment mobilization relative to the NAA due to changes in operations at Cottage Grove, Dorena, and Fern Ridge dams. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Cottage Grove and Dorena Reservoirs. Fern Ridge Reservoir would have a Negligible change. Sediment Re-Entrainment and Bank Failure Potential metric would have a Moderate change for Cottage Grove and Dorena Reservoirs. Fern Ridge Reservoir results in a Negligible change. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Cottage Grove, Dorena, and Fern Ridge dams. However, referencing River Mechanics and Geomorphology Section 3.3.2.7 “Alternative 3B has a Major change in shoreline exposure relative to the NAA for Cottage Grove and Dorena Dams. Fern Ridge Reservoir results in a Negligible change. Mercury has been studied in Cottage Grove and Dorena Dams as Total Mercury (inorganic) and Methylated Mercury (organic) in sediment Ambers et al. 2001; Eckley et al. 2015; Eckley et al. 2017).

*3.5.2.7.6 Mainstem Willamette River*

**Water Temperature**

Alternative 3B water temperature results for the Mainstem Willamette River at Salem (SLMO) results in a Negligible effect for Days below 18 C (64.4 F) (Summer). Results are not reported for “Days Near Temperature Target from April through August” or “Days Near Temperature Target from September through March” because there are no temperature targets (Figure 3.5-57; Table 3.5 23)).

Mainstem Willamette River results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the Willamette River near Salem gaging site (SLMO; Appendix D Figure 1-411) 2011-year scenario water temperature increases by 1 degree from May through August and decreases by 1 degree in September and October as compared to the NAA. In the 2015-year scenario temperature increases by 1 degree in May and October and decreases by 1 degree in July and September as compared to the NAA. In the 2016-year scenario water temperatures increase up to 2-degrees from May until July and then decreases by 1 degree in

September as compared to the NAA. For the average of the three years (2011,2015, 2016) water temperature increases by 1 degree in May and June and then decreases by 1 degree in September as compared to the NAA.

Alternative 3B water temperature results for the Mainstem Willamette River at Albany (ALBO) results in a Negligible effect for Days below 18 C (64.4 F) (Summer). Results are not reported for "Days Near Temperature Target from April through August" or "Days Near Temperature Target from September through March" because there are no temperature targets (Figure 3.5-57; Table 3.5 23).

Mainstem Willamette River results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the Willamette River at Albany gaging site (ALBO; Appendix D Figure 1-411) in the 2011-year scenario water temperatures increase up to 2 degrees from June through August and then decreases by 1 degree in October as compared to the NAA. In the 2015-year scenario water temperatures increase by 1-degrees in May and October as compared to the NAA. In the 2016-year scenario water temperatures increase up to 2-degrees from April through July and then decreases up to 2 degrees from August until October as compared to the NAA. For the average of the three years (2011,2015, 2016) water temperatures increase by 1-degrees from May until July and then decrease by 1-degree in September as compared to the NAA.

**TDG**

To the USACE knowledge, there are no TDG gages located on the Willamette River and TDG is presume not to be an issue, as this is a water quality parameter most affected by dam operations. Therefore, TDG gages are typically located downstream of WVS projects where there are known issues.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.7 and Technical Appendix C Potential for changes in sediment supply "there is Negligible potential for changes in sediment supply relative to the No Action Alternative in the Middle Willamette free-flowing reach".

**HABs**

To the USACE knowledge, there are no OHA HAB advisories near Albany and Salem in public records. At this time the USACE cannot control cyanobacteria bloom formation and growth. Further research is needed to determine factors that assist in toxin production and toxin suppression.

*Climate 3.5.2.7.7 Change*

Please reference Technical Appendices B and F for Climate Change qualitative effects. Compared to NAA, Alternative 3B would potentially have less resiliency against climate change effects on water temperature (decreased water temperature control) below Detroit, Hills Creek, and Lookout Point, and lower on the mainstem Willamette at Salem as a result of the lower storage and outflows at each location. However, Alternative 3B would potentially have more resiliency against climate change effects on water temperature (more normative temperatures) below Lookout Point-Dexter due to operational lake elevations. TDG levels will likely have more resiliency against climate change effects below Lookout Point-Dexter due to the reduced reservoir storage and expected hydrologic effects shown in Technical Appendix B (Hydrology and Hydraulics). Parameters such as Turbidity, HABs, and Mercury will likely experience similar effects as those described under NAA.

*3.5.2.7.8 Evaluation of Near-Term Operations Measure*

See Alternative 2A, Section 3.5.2.4, for description of effects due to the Near-Term Operations Measure.

**Table 3.5-22. Summary of Effects of Alternative 3B as compared to the NAA**

| Subbasin | Alternative 3B |
|---|---|
| North Santiam | Big Cliff has negligible effects for days near temperature targets ranges as compared to the NAA. Adverse effects to TDG levels are observed at Detroit and Big Cliff. |
| South Santiam | Foster observes negligible, beneficial, and adverse effects to measures for downstream water temperatures. Adverse effects to TDG levels are observed at Green Peter and Foster. |
| McKenzie | Cougar would have negligible to beneficial effects to water temperature measures. A beneficial effect to TDG is observed at Cougar. Blue River is not expected to change as the RO's are utilized and TDG levels would not be expected to change. |
| Middle Fork Willamette | Hills Creek would observe negligible, beneficial, and adverse effects to measures for downstream water temperatures. Dexter would observe negligible, beneficial, and adverse effects to measures for downstream water temperatures. Fall Creek temperatures would remain as described in the NAA. A negligible effect is observed for TDG at Hills Creek and Lookout Point. Dexter dam observe an adverse effects. |
| Coast Fork Willamette & Long Tom | There are no water temperature measures considered at Cottage Grove, Dorena, and Fern Ridge therefore conditions would remain similar to the NAA. There are no measures considered for TDG management therefore conditions would remain similar to the NAA. |

| Subbasin | Alternative 3B |
|---|---|
| Mainstem Willamette | Albany and Salem water temperatures observe negligible effects as compared to the NAA. TDG gages are not located on the Willamette River as TDG concerns are typically located downstream of WVS dams. |

### *3.5.2.7.9 Summary of Effects*

Below is provided a summary of Alternative 3B's overall water quality effects.

**Water Temperature**

Alternative 3B measures include operational improvements for water temperature: Utilizing the RO's to discharge cold water during drawdown operations in the fall and winter to reduce water temperatures below Detroit, Green Peter, and Lookout Point dams; Utilizing the spillway for surface spill in the summer at Detroit, Green Peter, Foster, Blue River, Hills Creek, and Lookout point dams. Modify existing outlets to allow releases at varying depths for temperature control: Modifying the spillway to allow releases at varying depths for temperature control at Blue River and Hills Creek dams; Lining of the lower RO tunnels to limit cavitation effects and to assist in temperature control at Detroit dam; Modifying the Cougar dam diversion tunnel for water temperature control and complying with dam safety. Monthly Mean of Daily Mean Water Temperature difference from NAA to Alternative 3B can be found in Appendix D Figure 1-411.

**Table 3.5-23. 3-year Average temperature difference with Effects Criteria of Alternative 3B as compared to NAA.**

| Location | Difference from NAA in Days Below 18C each year | Days Below 18C Effects Criteria | Annual Average Number of Days within 2 degrees F of Temperature Target (Apr-Aug) | Days Near Target (Apr-Aug) Effects Criteria | Annual Average Number of Days within 2 degrees F of Temperature Target (Sep-Mar) | Days Near Target (Sep-Mar) Effects Criteria |
|---|---|---|---|---|---|---|
| HCRO | -45 | Major Adverse | 31 | Moderate Benefit | 3 | Negligible |
| DEXO | -6 | Minor Adverse | 24 | Moderate Benefit | 7 | Negligible |
| CGRO | 0 | Negligible | 13 | Minor Benefit | 16 | Minor Benefit |
| SSFO | -45 | Major Adverse | 28 | Moderate Benefit | 0 | Negligible |
| BCLO | 0 | Negligible | -2 | Negligible | 3 | Negligible |
| ALBO | -2 | Negligible | NA | | NA | |

| Location | Difference from NAA in Days Below 18C each year | Days Below 18C Effects Criteria | Annual Average Number of Days within 2 degrees F of Temperature Target (Apr-Aug) | Days Near Target (Apr-Aug) Effects Criteria | Annual Average Number of Days within 2 degrees F of Temperature Target (Sep-Mar) | Days Near Target (Sep-Mar) Effects Criteria |
|---|---|---|---|---|---|---|
| SLMO | -2 | Negligible | NA | | NA | |

Please refer to Technical Appendix D for all Temperature model results by Alternative.
NA is due to no temperature targets for the Willamette during this period

**TDG**

There are no TDG abatement measures for Alternative 3B. A potential Moderate Adverse effect would be observed at Detroit and Big Cliff dams. A potential Minor Adverse effect would be observed at Green Peter, Foster, and Dexter dams. A potential Minor Benefit would be observed at Cougar Reservoir. A potential Negligible effect would be observed at, Hills Creek and Lookout Point dams (Figure 3.5-57; Table 3.5-24).

**Table 3.5-24. Compilation of TDG model results (Appendix D Figures 2-35;2-36;2-34; Figure 3.5-57) downstream of the dams for Alternative 3B.**

| Location | Average Number of Days Above 110% TDG | Annual Difference in Number of Days Above 110 % TDG compared to the No Action Alternative | Average Number of Days with Spill Per Year | Magnitude of Effects |
|---|---|---|---|---|
| DEX | 62 | 42 | 126 | Minor Adverse |
| LOP | 0 | 0 | 196 | Negligible |
| HCR | 19 | 0 | 89 | Negligible |
| CGR | 26 | -31 | 46 | Minor Benefit |
| FOS | 69 | 37 | 211 | Minor Adverse |
| GPR | 62 | 50 | 235 | Minor Adverse |
| BCL | 226 | 78 | 125 | Moderate Adverse |
| DET | 203 | 87 | 197 | Moderate Adverse |

**Turbidity**

There are no measures for Turbidity however sites are qualitatively described in the below sections. Potential Changes in Sediment Supply within the River Mechanics and Geomorphology Section 3.3 and Technical Appendix C is utilized for comparison.

**HABs**

There are no measures for Harmful Algae Blooms however sites are qualitatively described in the below sections. River Mechanics and Geomorphology analysis of Head-of-Reservoir, Shoreline Exposure and Sediment Re-Entrainment and Bank Failure Potential within Section 3.3 and Technical Appendix C is utilized for comparison.

**Mercury**

There are no WVS EIS Alternative measures for Mercury however sites are qualitatively described in the below sections. Shoreline Exposure analysis within the River Mechanics and Geomorphology Section 3.3 and Technical Appendix C is utilized.

### *3.5.2.8 Alternative 4 – Structures-Based Fish Passage Alternative*

This section describes the Alternative 4 effects to water quality.

#### *3.5.2.8.1 North Santiam Dam*

**Water Temperature**

Alternative 4 measure at Detroit Reservoir includes a water temperature control tower.

Big Cliff/ Detroit Dams would have a Negligible effect of days below 18C (Summer), Moderate Benefit for Days Near Temperature Target from April through August, and Major Benefit for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5 26).

Alternative 4 results as compared to the NAA the Monthly Mean of Daily Mean water temperatures at the North Santiam at Niagara gaging site (BCLO; Appendix D Figure 1-419) in the 2011-year scenario see water temperature increase up to 3 degrees starting in June through October. In the 2015-year scenario water temperatures would increase 2 to 3 degrees from May to August and then decrease up to 6 degrees in September and October. In the 2016-year scenario water temperatures would increase up to 11 degrees from May to September and then decrease by 2 degrees in October. For the average of the three years (2011,2015,2016) water temperatures would increase up to 6 degrees from May until September and then decrease by 2 degrees in October.

**TDG**

Structural improvement measures to improve TDG at Detroit Reservoir is included in the design of the proposed water temperature control tower under Alternative 4. Detroit Reservoir has a Moderate Beneficial effect and Big Cliff Reservoir has a Major Beneficial effect with Alternative 4 measures (Figure 3.5-57; Table 3.5 27).

Under Alternative 4, the average number of days above 110% TDG levels at Big Cliff is 37 and Detroit is 39 (Figure 2-35). Observing the Annual difference in number of days above 110% of

TDG exceedances Big Cliff has a reduction of 111 days and Detroit has a reduction of 77 days as compared to the No Action Alternative (Figure 2-36). The Average Number of Days of Spill per year at Big Cliff is 86 days and Detroit is 62 (Figure 2-34).

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.8 Potential for changes in sediment supply section, which states "there is Moderate change in sediment supply with additional fine-grained sediments passing into the Big Cliff run-of-reservoir. Increased fine-grained sediment supply is due deeper drafts in Detroit dams that have potential to induce bank erosion and sloughing. A Minor change in fine-grained sediment supply to the North Fork Santiam River downstream of Big Cliff dam".

**HABs**

Please refer to River Mechanics and Geomorphology Section 3.3.2.8, which states Deeper drawdowns are typically occurring during lower flow periods, such that Alternative 4 has Negligible change in the potential for head-of-reservoir sediment mobilization and sediment trap efficiency at all WVS storage projects. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Detroit Reservoir. Sediment Re-Entrainment and Bank Failure Potential metric would have a Major change for Detroit Reservoir. Big Cliff Reservoir is a run-of river project that operates in a small range of pool elevations and is not included for these metrics. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Detroit. Big Cliff reservoir is a run-of river project that operates in a small range of pool elevations and is not included for this metric. Please refer River Mechanics and Geomorphology Section 3.3.2.8 for qualitative analysis of Alternative 4 as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Detroit dam. Currently the amount or levels of mercury in Detroit is unknown. As there is Major change in shoreline exposure at Detroit dam there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.8.2 South Santiam Dams*

**Water Temperature**

Alternative 4 measures at Green Peter Reservoir include utilizing the RO's to discharge colder water during drawdown operation in the fall and winter to reduce downstream water temperatures. The Green Peter spillway is used for surface spill in the summer. At Foster

Reservoir the existing outlets would be modified to allow releases at varying depths for temperature control through a Forebay Warm Water Supply (FWWS) pipe and fish weirs.

Green Peter/Foster Dams has a Major Benefit effect for Days below 18 C (64.4 F) (Summer), Minor Benefit for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5 26*0*).

Alternative 4 results as compared to the NAA the Monthly Mean of Daily Mean water temperatures at the South Santiam River near Foster gaging site (SSFO; Appendix D Figure 1-420) in the 2011-year scenario water temperatures would increase up to 5 degrees from May until September, although a 2-degree decrease occurs in July. In the 2015-year scenario water temperatures would increase up to 5 degrees from April to June and then decrease up to 13 degrees from July through October. In the 2016-year scenario water temperatures would increase up to 5 degrees from April to August and then decrease by 2 degrees in October. For the average of the three years water temperatures would increase up to 4 degrees from April until June and decrease up to 2 degrees from July through October.

**TDG**

Structural improvement measures to improve TDG at Foster Reservoir are included at the Foster adult fish collection facility. Foster Reservoir would have a Negligible effect and Green Peter Reservoir would have a Major Adverse effect for Alternative 4 measures (Figure 3.5-57; Table 3.5 27).

Under Alternative 4, the average number of days above 110% TDG levels at Green Peter is 135 days and Foster is 19 days (Appendix D Figure 2-35). Observing the Annual difference in number of days above 110% of TDG exceedances Green Peter has an increase of 123 days and Foster is decreased to 13 days as compared to the No Action Alternative (Appendix D Figure 2-36). The Average Number of Days of Spill per year at Green Peter is 185 days and Foster is 211 days (Appendix D Figure 2-34).

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.8 Potential for changes in sediment supply section "there is the potential for Moderate change in sediment supply with additional fine-grained sediments passing into Foster Reservoir. Increased fine-grained sediment supply is due deeper drafts in Green Peter Reservoir that have potential to induce bank erosion and sloughing. There is potential for a Minor change in fine-grained sediment supply to the South Fork Santiam River downstream of Foster Dam. Increased fine-grained sediment supply is due to deeper drafts in Green Peter Reservoir that may pass sediment through Green Peter dam and partially through Foster Reservoir".

**HABs**

Please refer to River Mechanics and Geomorphology Section 3.3.2.8, which states "Deeper drawdowns are typically occurring during lower flow periods, such that Alternative 4 has Negligible change in the potential for head-of-reservoir sediment mobilization and sediment trap efficiency at all WVS storage projects. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Green Peter Reservoir and Negligible for Foster Reservoir. Sediment Re-Entrainment and Bank Failure Potential metric would have a Major change for Green Peter reservoir and Negligible for Foster Reservoir. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Green Peter and Foster. Please refer River Mechanics and Geomorphology Section 3.3.2.8 for the qualitative analysis of Alternative 4 as compared to the NAA. "The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Green Peter reservoir and Negligible for Foster reservoir. Currently the amount or levels of mercury in Green Peter and Foster reservoirs is unknown. As there is Major change in shoreline exposure at Green Peter dam there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.8.3 McKenzie Dams*

**Water Temperature**

There are no temperature measures in Alternative 4 for Cougar or Blue River dams. South Fork McKenzie River near Rainbow site (CGRO) is downstream of Blue River and Cougar Dam and would see a Negligible effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5 26).

Results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the South Fork McKenzie River near Rainbow gaging site (CGRO; Appendix D Figure 1-421) in the 2011-year scenario water temperature would decrease by 1 degree from May until August. In the 2015-year scenario a decrease up to 3 degrees from July to October. In the 2016-year scenario a decrease is observed up to 2 degrees in July and increase of 4 degrees in August and September. For the Average of the three years (2011, 2015, 2016) water temperature decreases up to 2 degrees from June until August and then increase by 1 degree in September.

**TDG**

Cougar dams has a Minor Benefit when including the structural improvement for TDG management measure in Alternative 4 as compared to the NAA (Figure 3.5-57; Table 3.5 27).

Under Alternative 4, the average number of days above 110% TDG levels at Cougar is 17 days. Observing the Annual difference in number of days above 110% of TDG exceedance Cougar is decreased to 41 days as compared to the No Action Alternative. The Average Number of Days of Spill per year at Cougar is 168 days.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.8 Potential for changes in sediment supply section "there is Minor change in sediment supply with additional fine-grained sediments passing out of Cougar downstream into the McKenzie River. Increased fine-grained sediment supply is due to deeper drafts that may pass fine-grained sediment out of Cougar Reservoir. Blue River Reservoir would have a potential for a Moderate change in fine-grained sediment supply. Increased fine-grained sediment supply is due to deeper drafts in Blue River

**HABs**

Please refer to River Mechanics and Geomorphology Section 3.3.2.8, which states Deeper drawdowns are typically occurring during lower flow periods, such that Alternative 4 has Negligible change in the potential for head-of-reservoir sediment at all WVS storage projects. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Cougar and Blue River dams. Sediment Re-Entrainment and Bank Failure Potential metric would have a Moderate change for Cougar and Major change for Blue River dams. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Cougar and Blue River. Please refer to River Mechanics and Geomorphology Section 3.3.2.8 for the qualitative analysis of Alternative 4 as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Cougar and Blue River dams. Currently the amount or levels of mercury in Cougar and Blue River is unknown. As there is Major change in shoreline exposure at Cougar and Blue River dams there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

#### *3.5.2.8.4 Middle Fork Willamette Dams*

**Water Temperature**

Alternative 4 measures at Hills Creek and Lookout Point dams include water temperature control towers to better regulate downstream water temperatures. There are no Alternative 4 temperature measures for Dexter or Fall Creek Reservoirs.

Lookout Point/Dexter Dams would see a Major Adverse effect for Days below 18 C (64.4 F) (Summer), Negligible effect for Days Near Temperature Target from April through August, and Negligible effect for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5 26).

As compared to the NAA the Monthly Mean of Daily Mean water temperatures at the Middle Fork Willamette River near Dexter gaging site (DEXO; Appendix D Figure 1-422) in the 2011-year scenario water temperature would increase starting in April through September up to 8 degrees and decrease by 6 degrees in October. In the 2015-year scenario water temperature would increase up to 3 degrees in April and May and then decrease up to 3 degrees from August to October. In the 2016-year scenario water temperatures would increase up to 5 degrees from April to August and then decrease up to 6 degrees in September and October. For the average of the three years water temperatures would increase up to 4 degrees from April through August and then decrease up to 5 degrees in September and October.

Hills Creek dam has a Major Adverse for Days below 18 C (64.4 F) (Summer), Major Benefit for Days Near Temperature Target from April through August, and Moderate Benefit for Days Near Temperature Target from September through March (Figure 3.5-57; Table 3.5 26)

As compared to the NAA the Monthly Mean of Daily Mean water temperatures at the Middle Fork Willamette River above Salt Creek gaging site (HCRO; Appendix D Figure 1-423) in the 2011-year scenario water temperatures would increase up to 12 degrees from April through September and then decrease by 5 degrees in October. In the 2015-year scenario water temperatures would increase up to 6 degrees from April through August and then decrease by 3 degrees in October. In the 2016-year scenario water temperatures would increase up to 9 degrees from April through August and then decrease by 7 degrees in September and October. For the average of the three years (2011,2015,2016) water temperatures would increase up to 8 degrees from April through August and then decrease up to 5 degrees in September and October.

**TDG**

Alternative 4 measures include structural improvements for TDG at Lookout Point Reservoir within the water temperature control tower. Dexter Reservoir includes structural improvements to reduce TDG and mechanical degassing methods in the fish collection/hatchery areas downstream of the dam. Lookout Point, Dexter, and Hills Creek dams would have a Negligible effect with Alternative 4 TDG measures as compared to the NAA (Figure 3.5-57; Table 3.5 27).

Under Alternative 4, the average number of days above 110% TDG levels at Hills Creek is 9 days, Lookout Point is 0 days, and Dexter is 5 days (Appendix D Figure 2-35). Observing the Annual difference in number of days above 110% of TDG exceedances Hills Creek is reduced by 9 days, Lookout Point is 0 days, and Dexter is reduced by 15 days as compared to the No Action Alternative (Appendix D Figure 2-36). The Average Number of Days of Spill per year at Hills Creek is 123 days, Lookout Point is 49 days, and Dexter is 91 days (Appendix D Figure 2-34).

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.8 Potential for changes in sediment supply section there is Moderate change in sediment supply with additional fine-grained sediments passing into Hills Creek Reservoir. Increased fine-grained sediment supply is due deeper drafts in Hills Creek Reservoir that have potential to induce bank erosion and sloughing. There is potential for a Minor change in fine-grained sediment supply to the Dexter run-of-river reservoir. Increased fine-grained sediment supply is due to deeper drafts in Lookout Point Reservoir that may pass sediment due to reduction in reservoir storage volume.

**HABs**

Please refer to River Mechanics and Geomorphology Section 3.3.2.8, which states Deeper drawdowns are typically occurring during lower flow periods, such that Alternative 4 has Negligible change in the potential for head-of-reservoir sediment mobilization at all WVS storage projects. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Hills Creek and Lookout Point Reservoirs. Fall Creek Reservoir would result in a Negligible change. Sediment Re-Entrainment and Bank Failure Potential metric would have a Major change for Hills Creek, Minor change for Lookout Point, and Negligible change for Fall Creek Reservoirs. Dexter Reservoir is a run-of river project that operates in a small range of pool elevations and is not included in these metrics. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Hills Creek, Lookout Point and Fall Creek. Please refer to River Mechanics and Geomorphology Section 3.3.2.8 for the qualitative analysis of Alternative 4 as compared to the NAA. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Hills Creek and Lookout Point Reservoirs. Fall Creek reservoir would result in a Negligible change”. Dexter reservoir is a run-of river project that operates in a small range of pool elevations and is not included in this metric. Currently the amount or levels of mercury in Hills Creek, Lookout Point, and Fall Creek is unknown. As there would be changes in shoreline exposure at Hills Creek and Lookout Point dams there is potential for an increase for the methylation process to occur with water fluctuations. Changes in shoreline exposure is a long-term, direct effect.

*3.5.2.8.5 Coast Fork Dams and Long Tom*

**Water Temperature**

There are no temperature measures for Cottage Grove, Dorena, Fern Ridge dams under Alternative 4. Conditions would remain as described in the No Action Alternative and Water Quality Affected Environment.

**TDG**

There are no TDG measures at Cottage Grove, Dorena and Fern Ridge dams under Alternative 4, conditions would remain as described in the No Action Alternative and Water Quality Affected Environment. TDG exceedance may occur if water is released through the non-turbine outlets of dams, spill and maintenance operations.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.8 Potential for changes in sediment supply section there is the potential for Moderate change in sediment supply with additional fine-grained sediments passing into the Coast Fork Willamette and Row River free-flowing reaches from Cottage Grove and Dorena River. Increased fine-grained sediment supply is due deeper drafts in Cottage Grove and Dorena dams that have potential to induce bank erosion and sloughing. There is Negligible result in sediment supply relative to the NAA in the Long Tom river free-flowing reach". Increased suspended sediments may cause an elevation in turbidity levels during drawdown operations or precipitation events.

**HABs**

Please refer to River Mechanics and Geomorphology Section 3.3.2.8, which states Deeper drawdowns are typically occurring during lower flow periods, such that Alternative 4 has Negligible change in the potential for head-of-reservoir sediment mobilization at all WVS storage projects. The Shoreline Exposure metric within Section 3.3 and Technical Appendix C would have a Major change for Cottage Grove and Dorena Reservoirs. Fern Ridge Reservoir results in a Negligible change. Sediment Re-Entrainment and Bank Failure Potential metric would have a Moderate change for Cottage Grove and Dorena Reservoirs. Fern Ridge Reservoir results in a Negligible change. These metrics provide a qualitative analysis to describe potential nutrient availability within sediments for algae.

**Mercury**

There are no WVS EIS Alternative measures for Mercury within Cottage Grove, Dorena, and Fern Ridge dams. Please refer to River Mechanics and Geomorphology Section 3.3.2.8 Shoreline Exposure has a Major change in bank exposure relative to the NAA for Cottage Grove and Dorena Dams. Fern Ridge Reservoir results in a Negligible change. Mercury has been studied in Cottage Grove and Dorena Dams as Total Mercury (inorganic) and Methylated Mercury (organic) in sediment (Ambers et al. 2001; Eckley et al. 2015; Eckley et al. 2017).

#### *3.5.2.8.6 Mainstem Willamette River*

**Water Temperature**

Alternative 4 water temperature within the Mainstem Willamette River at Salem (SLMO) results in a Minor Adverse effect for Days below 18 C (64.4 F) (Summer). Results are not reported for "Days Near Temperature Target from April through August" or "Days Near Temperature Target from September through March" because there are no temperature targets (Figure 3.5-57; Table 3.5-26).

Mainstem Willamette River Alternative 4 results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the Willamette River near Salem gaging site (SLMO; Appendix D Figure 1-418) 2011-year scenario water temperature increases by 1 degree in June and August to September and decreases by 1 degree in October as compared to the NAA. In the 2015-year scenario temperature increases up to 2 degrees from April to May and decreases up to 2 degrees in July and September as compared to the NAA. In the 2016-year scenario water temperatures increase by 1-degrees from May until July and then decreases by 1 degree in October as compared to the NAA. For the average of the three years (2011,2015, 2016) water temperature increases by 1 degree in May as compared to the NAA.

Alternative 4 water temperature within the Mainstem Willamette River at Albany (ALBO) results in a Negligible effect for Days below 18 C (64.4 F) (Summer). Results are not reported for "Days Near Temperature Target from April through August" or "Days Near Temperature Target from September through March" because there are no temperature targets (Figure 3.5-57; Table 3.5-26).

Mainstem Willamette River Alternative 4 results are compared to the NAA the Monthly Mean of Daily Mean water temperatures at the Willamette River at Albany gaging site (ALBO; Appendix D Figure 1-418) in the 2011-year scenario water temperatures increase up to 2 degrees from July through September and then decreases by 2 degrees in October as compared to the NAA. In the 2015-year scenario water temperatures increase by 1-degrees in April and May and then decreases by 1 degree in July and August as compared to the NAA. In the 2016-year scenario water temperatures increase up to 2-degrees from April through August and then decreases by 1 degree from September through October as compared to the NAA. For the average of the three years (2011,2015, 2016) water temperatures increase by 1-degrees in April through May and August and then decrease by 1-degree in October as compared to the NAA.

**TDG**

To the USACE knowledge, there are no TDG gages located on the Willamette River and TDG is presume not to be an issue, as this is a water quality parameter most affected by dam operations. Therefore, TDG gages are typically located downstream of WVS projects where there are known issues.

**Turbidity**

An increase in suspended sediments may cause an elevation in turbidity levels during drawdown operations, low flow or precipitation events. Please refer to River Mechanics and Geomorphology Section 3.3.2.8 and Technical Appendix C Potential for changes in sediment supply “there is Negligible potential for changes in sediment supply relative to the No Action Alternative in the Middle Willamette free-flowing reach”.

**HABs**

To the USACE knowledge, there are no OHA HAB advisories near Albany and Salem in public records. At this time the USACE cannot control cyanobacteria bloom formation and growth. Further research is needed to determine factors that assist in toxin production and toxin suppression.

*3.5.2.8.7 Climate Change*

Please reference Technical Appendices B and F for Climate Change qualitative effects. Compared to NAA, Alternative 4 would potentially have more resiliency against climate change effects on water temperature and TDG (increased water temperature control) below Detroit, Lookout Point, and Hills Creek as a result of the proposed SWS and TDG abatement measures at each location. Parameters such as Turbidity and Mercury will likely experience similar effects as those described under NAA. Increased releases from the lake surface via the proposed SWS at Detroit, Lookout Point, and Hills Creek combined with reduced summer flow volumes under Alternative 1 could lead to increased phytoplankton (algae) compared to NAA (Technical Appendix B Hydrology and Hydraulics).

*3.5.2.8.8 Evaluation of Near-Term Operations Measure*

See Alternative 2A, Section 3.5.2.4, for description of effects due to the Near-Term Operations Measure.

**Table 3.5-25. Summary of Effects of Alternative 4 as compared to the NAA**

| Subbasin | Alternative 4 |
|---|---|
| North Santiam | Big Cliff has negligible to beneficial effects for downstream water temperatures. Beneficial effects to TDG levels are observed at Detroit and Big Cliff. |
| South Santiam | Foster observes negligible to beneficial effects to downstream water temperatures. Negligible to adverse effects to TDG levels is observed at Green Peter and Foster. |
| McKenzie | Cougar observes negligible l effects to water temperature measures. A beneficial effect to TDG is observed at Cougar. Blue River is not expected to change as the RO’s are utilized and TDG levels would not be expected to change. |

| Subbasin | Alternative 4 |
|---|---|
| Middle Fork Willamette | Hills Creek would observe beneficial and adverse effects to measures for downstream water temperatures. Dexter would observe negligible and adverse effects to measures for downstream water temperatures. Fall Creek temperatures would remain as described in the NAA. A negligible effect is observed for TDG at Hills Creek, Lookout Point and Dexter. |
| Coast Fork Willamette & Long Tom | There are no water temperature measures considered at Cottage Grove, Dorena, and Fern Ridge therefore conditions would remain similar to the NAA. There are no measures considered for TDG management therefore conditions would remain similar to the NAA. |
| Mainstem Willamette | Albany and Salem water temperatures observe negligible to adverse effects as compared to the NAA. TDG gages are not located on the Willamette River as TDG concerns are typically located downstream of WVS dams. |

#### *3.5.2.8.9 Summary of effects*

Below is provided a summary of Alternative 4's overall water quality effects.

**Water Temperature**

Alternative 4 structural improvements for water temperature measures include: Water temperature control towers at Detroit, Hills Creek, and Lookout Point dams; Modify existing outlets to allow releases at varying depths for temperature control at Foster Reservoir through a Facility Warm Water Supply (FWWS) pipe and fish weirs. Utilizing the RO's to discharge cold water during drawdown operations in the fall and winter to reduce water temperatures below Green Peter dam. Utilizing the spillway for surface spill in the summer at Green Peter dam. Monthly Mean of Daily Mean Water Temperature differences from the NAA to Alternative 4 can be found in Appendix D Figure 1-418.

**Table 3.5-26. 3-year Average temperature difference with Effects Criteria of Alternative 4 as compared to NAA**

| Location | Difference from NAA in Days Below 18C each year | Days Below 18C Effects Criteria | Annual Average Number of Days within 2 degrees F of Temperature Target (Apr-Aug) | Days Near Target (Apr-Aug) Effects Criteria | Annual Average Number of Days within 2 degrees F of Temperature Target (Sep-Mar) | Days Near Target (Sep-Mar) Effects Criteria |
|---|---|---|---|---|---|---|
| HCRO | -27 | Major Adverse | 64 | Major Benefit | 24 | Moderate Benefit |

| Location | Difference from NAA in Days Below 18C each year | Days Below 18C Effects Criteria | Annual Average Number of Days within 2 degrees F of Temperature Target (Apr-Aug) | Days Near Target (Apr-Aug) Effects Criteria | Annual Average Number of Days within 2 degrees F of Temperature Target (Sep-Mar) | Days Near Target (Sep-Mar) Effects Criteria |
|---|---|---|---|---|---|---|
| DEXO | -15 | Major Adverse | 4 | Negligible | -2 | Negligible |
| CGRO | 0 | Negligible | 2 | Negligible | -1 | Negligible |
| SSFO | 19 | Major Benefit | 15 | Minor Benefit | 6 | Negligible |
| BCLO | 0 | Negligible | 42 | Moderate Benefit | 58 | Major Benefit |
| ALBO | -4 | Negligible | NA | | NA | |
| SLMO | -5 | Minor Adverse | NA | | NA | |

Please refer to Technical Appendix D for all Temperature model results by Alternative.
NA is due to no temperature targets for the Willamette during this period

**TDG**

Alternative 4 includes structural improvement measures to reduce TDG at Detroit, Green Peter, Foster, Lookout Point, Dexter, and Cougar dams. Detroit and Lookout Point dams TDG measure would be incorporated into the water temperature control tower design. A mechanical degassing method is included at the AFF for TDG reduction at Big Cliff and Dexter dams.

Green Peter Reservoir has a potential Major Adverse effect. Detroit Reservoir would potentially have a Moderate Benefit. Cougar Reservoir would have a potential Minor Benefit from structural improvements for TDG. A Negligible effect would be observed at Foster, Hills Creek, Lookout Point, and Dexter dams (Figure 3.5-57; Table 3.5-27).

**Table 3.5-27. Compilation of TDG model results (Appendix D Figures 2-35;2-36;2-34; Figure 3.5-57) downstream of the dams for Alternative 4.**

| Location | Average Number of Days Above 110% TDG | Annual Difference in Number of Days Above 110 % TDG compared to the No Action Alternative | Average Number of Days with Spill Per Year | Magnitude of Effects |
|---|---|---|---|---|
| DEX | 5 | -15 | 91 | Negligible |
| LOP | 0 | 0 | 49 | Negligible |
| HCR | 9 | -9 | 123 | Negligible |
| CGR | 17 | -41 | 168 | Minor Benefit |

| Location | Average Number of Days Above 110% TDG | Annual Difference in Number of Days Above 110 % TDG compared to the No Action Alternative | Average Number of Days with Spill Per Year | Magnitude of Effects |
|---|---|---|---|---|
| FOS | 19 | -13 | 285 | Negligible |
| GPR | 135 | 123 | 165 | Major Adverse |
| BCL | 37 | -111 | 86 | Major Benefit |
| DET | 39 | -77 | 62 | Moderate Benefit |

**Turbidity**

There are no measures for Turbidity however sites are qualitatively described in the below sections. Potential Changes in Sediment Supply within the River Mechanics and Geomorphology Section 3.3 and Technical Appendix C is utilized for comparison.

**HABs**

There are no measures for Harmful Algae Blooms however sites are qualitatively described in the below sections. River Mechanics and Geomorphology analysis of Head-of-Reservoir, Shoreline Exposure and Sediment Re-Entrainment and Bank Failure Potential within Section 3.3 and Technical Appendix C of is utilized for comparison.

**Mercury**

There are no WVS EIS Alternative measures for Mercury however sites are qualitatively described in the below sections. Shoreline Exposure analysis within the River Mechanics and Geomorphology Section 3.3 and Technical Appendix C is utilized.

#### *3.5.2.9 Alternative 5. Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 5 impacts are similar to Alternative 2B except the integrated temperature and habitat flow regime (Measure #30a as described in Section 2.2.1.1) has been replaced by the refined integrated temperature and habitat flow regime (Measure #30b as described in Section 2.2.1.2 and Appendix A). Refer to impact descriptions in Alternative 2B, Section 3.5.2.5 for all Alternative 5 regions and effects. Please see Technical Appendix D for metric calculations and supporting figures for Water Temperature and TDG.

*3.5.2.9.1 North Santiam Dams*

**Water Temperature**

Alternative 5 includes a Water Temperature Control tower at Detroit reservoir for water temperature management. Because of the similarities in operations and structural assumptions for Alternative 5 and Alternative 2B in the North Santiam, refer to Appendix D Section 1.6.4.1 for a comparison of Alternative 2B and NAA water temperature effects at Detroit and Big Cliff Dams.

Lake level and storage at Detroit Lake in Alternative 5 was identical to Alternative 2B in 2011, 2015, and 2016. Compared to NAA, Alternative 5 lake levels were generally higher in 2015 and 2016 aside from September-November in 2015 where the power pool was utilized for downstream flow augmentation (Appendix D). The increased storage compared to NAA coincided with reduced outflows during spring and increased outflows in summer during 2015 and 2016 under Alternative 5. Total outflow in 2011 was generally similar in Alternative 5 and NAA at Detroit Lake. The proposed SWS and FSS in Alternative 5 allowed all outflow within powerhouse capacity (assumed at 4600 cfs) to be routed from a floating outlet through the Power outlets for temperature management, rather than the Spillway or URO flow for temperature management that was used in NAA (Appendix D Figure 1-359).

**TDG**

Under Alternative 5 there are no measures for TDG abatement at Detroit and Big Cliff. Detroit Reservoir has a Moderate Beneficial effect and Big Cliff Reservoir has a Major Beneficial effect with Alternative 5 measures (Figure 3.5-57; Table 3.5-29).

Under Alternative 5, the average number of days above 110% TDG levels at Big Cliff is 79 and Detroit is 39 (Appendix D Figure 2-35; Table 3.5-29). North Santiam Alternative 5 TDG effects essentially match those in Alternative 2B with Big Cliff resulting in a reduction of 69 number of days in annual difference the above 110% TDG and Detroit reduced by 77 days as compared to the No Action Alternative (Appendix D Figure 2-36). The Average Number of Days of Spill per year at Detroit is 62 days and Big Cliff is 86 days (Appendix D Figure 2-34).

*3.5.2.9.2 South Santiam Dams*

**Water Temperature**

Alternative 5 includes the use of the RO’s to discharge colder water during fall and winter drawdown operations at Green Peter reservoir. Additional measures include use of the spillway for surface spill in the summer at Green Peter reservoir and a measure to modify existing outlets to allow releases at varying depths for temperature control specifically at Foster reservoir with a modification to the Facility Warm Water Supply (FWWS) pipe and fish weirs. Because of the similarities in operations and structural assumptions for Alternative 5 and

Alternative 2B in the South Santiam, refer to Appendix D for a comparison of Alternative 2B and NAA water temperature effects at Green Peter and Foster Dams.

Lake level and storage at Green Peter in Alternative 5 was nearly identical to Alternative 2B in 2011, 2015, and 2016. Compared to NAA, Alternative 5 lake levels were generally higher in 2011, 2015, and 2016 aside from October-November during RO drawdown for fish passage (Appendix D Figure 1-361, Figure 1-362, and Figure 1-363). Some increased storage in 2015 coincided with reduced outflows during spring and increased outflows in July-October comparing Alternative 5 to NAA. 2011 and 2016 operations were generally similar in Alternative 5 and NAA at Green Peter Lake January-June but followed increased outflows in July-October to draft the lake for fish passage operations through the ROs in autumn. The proposed operational temperature management through the spillway (during spring/summer) and RO (during autumn) in Alternative 5 led to increased outflow from these outlets and decreased power outflow compared to NAA (Appendix D Figure 1-362).

Lake level and storage at Foster in Alternative 5 was nearly identical to Alternative 2B in 2011, 2015, and 2016. Compared to NAA, Alternative 5 lake levels were generally similar in 2011 and 2016 but increased in 2015 under Alternative 5 compared to NAA (Appendix D Figure 1-364, Figure 1-365, and Figure 1-366). Total outflow from Foster Dam was affected by upstream operations at Green Peter Dam. The proposed modifications to the fish weir and FWWS in Alternative 5 resulted in lower outflow routed through the Power outlets for temperature management, especially during spring and summer, compared to NAA (Appendix D Figure 1-362).

**TDG**

There are no TDG measures within Alternative 5 for Green Peter and Foster reservoirs. Foster Reservoir would have a Negligible effect and Green Peter Reservoir would have a Moderate Adverse effect for Alternative 5 measures (Figure 3.5-57; Table 3.5-29).

South Santiam Alternative 5 TDG effects match those in Alternative 2B, with the average number of days above 110% TDG levels at Green Peter 151 days and Foster at 126 days (Appendix D Figure 2-35; Table 3.5-29). Green Peter results in an increase of 139 days of TDG exceedances and Foster is increased by 94 days as compared to the No Action Alternative (Appendix D Figure 2-36). The Average Number of Days of Spill per year at Green Peter is 190 days and Foster is 284 days (Appendix D Figure 2-34).

#### *3.5.2.9.3 McKenzie Dams*

**Water Temperature**

There are no water temperature measures for Cougar or Blue River dams under Alternative 2B. Because of the similarities in operations and structural assumptions for Alternative 5 and Alternative 2B in the McKenzie River, refer to Appendix D Section 1.6.4.3 for a comparison of Alternative 2B and NAA water temperature effects at Cougar Dam.

Lake level and storage at Cougar in Alternative 5 was nearly identical to Alternative 2B in 2011, 2015, and 2016. Compared to NAA, Alternative 5 lake levels were lower in 2011, 2015, and 2016 to allow for proposed fish passage operations through the diversion tunnel (Appendix D Figure 1-367, Figure 1-368, and Figure 1-369). The decreased storage coincided with reduced outflows during spring and summer (Appendix D Figure 1-367). Outflows were primarily routed through the diversion tunnel in Alternative 5, except when the lake refilled to about 30 feet above the RO intake (e.g., 2011).

**TDG**

There are no TDG management measures for Alternative 5 for Cougar Reservoir. Cougar dams has a Minor Benefit under Alternative 5 as compared to the NAA (Figure 3.5-57; Table 3.5-29).

Under Alternative 5, the average number of days above 110% TDG levels at Cougar is 13 days (Appendix D Figure 2-35; Table 3.5-29). The minimal change from Alternative 5 to Alternative 2B is likely due to differences in the draft rate during the spring drawdown at Cougar (for more information, see Appendix D Section 1.5.8.3.1 and Section 3.2 Hydrologic Processes and Technical Appendix B Hydrology and Hydraulics). Observing the Annual difference in number of days above 110% of TDG exceedance Cougar is decreased by 49 days as compared to the No Action Alternative (Appendix D Figure 2-36). The Average Number of Days of Spill per year at Cougar is 29 days (Appendix D Figure 2-34).

#### *3.5.2.9.4 Middle Fork Willamette Dams*

**Water Temperature**

Alternative 5 has no water temperature measures for Hills Creek Dam. The primary differences related to the expected water temperature below Hills Creek Dam in Alternative 5 and Alternative 2B are related to the timing and extent of the lake drafting in 2015 and 2016. The differences compared to Alternative 2B in the drawdown are limited to about 2 weeks in 2015 and 2-4 weeks in 2016 (Appendix D Figure 1-370). The downstream temperature associated with these differences would likely be Minor and represented by a Minor to Negligible temporal shift (backward in time) of the temperature signal (Appendix D Figure 1-188) during June-July of 2015 and July-September of 2016. The deeper draft and use of the RO at Hills Creek in Alternative 5 during September of 2016 compared to Alternative 2B may result in warmer surface water releases during September followed by cooler releases in October as the lake is allowed to equilibrate with the ambient air sooner in the autumn. Given the brief and variable (relatively warmer and cooler) periods in which these differences from Alternative 2B occur, it is expected that Alternative 5 water temperature impacts would be likely be negligibly different than the metrics shown in Appendix D Figure 1-379, Figure 1-380, and Figure 1-381.

Lake level and storage at Hills Creek in Alternative 5 were nearly identical to Alternative 2B in 2011 and 2015. Operational differences between Alternative 5 and Alternative 2B in 2016 are likely a result of RES-SIM using Hills Creek to meet mainstem flow targets at Salem during

September. Compared to NAA, Alternative 5 lake levels were generally increased in the refill periods of 2015 and 2016 (early summer) before the lake was drafted and the power pool was utilized for downstream flow augmentation (Appendix D Figure 1-370, Figure 1-371, and Figure 1-372). The increased storage coincided with reduced outflows during spring and increased outflows in May-June during 2015 and August-October in 2016 (Appendix D Figure 1-371). 2011 operations were generally similar in Alternative 5, Alternative 2B, and NAA at Hills Creek Lake.

Alternative 5 has no water temperature measures for Lookout Point Dam and operations in Alternative 5 closely resemble those in Alternative 2B (Appendix D). It is likely that the Negligible temperature effects from Hills Creek operations would be Negligible, relatively short-lived (days to weeks) when incorporated into the proposed Alternative 5 operations at Lookout Point and Dexter Dams. Because of the similarities in operations and structural assumptions for Alternative 5 and Alternative 2B at Lookout Point, refer to Appendix D Section 1.6.4.4 for a comparison of Alternative 2B and NAA water temperature effects.

Lake level and storage at Lookout Point in Alternative 5 were similar to Alternative 2B and NAA in 2011, 2015, and 2016 (Appendix D Figure 1-373, Figure 1-374, and Figure 1-375) aside from minor differences in timing of refill and release rates that were associated with upstream Hills Creek Dam operations.

**TDG**

Under Alternative 5 there are no TDG measures for Hills Creek, Lookout Point and Dexter dams although model analysis has determined effects to the sub-basin. Lookout Point, Dexter, and Hills Creek dams would have a Negligible effect with Alternative 5 TDG measures as compared to the NAA (Figure 3.5-57; Table 3.5-29).

Middle Fork Willamette Alternative 5 TDG effects essentially match those in Alternative 2B, with Lookout Point resulting in a reduction of 0 days and on average 0 days of TDG exceedance for the year (Appendix D Figure 2-35; Table 3.5-29) compared to NAA. Dexter dam has reduction of 16 days and on average 5 days of TDG exceedance for the year (Appendix D Figure 2-35) compared to NAA. Hills Creek dam has a reduction of 3 days of Annual Difference in Number of Days above 110% and on average number of days exceeds TDG by 18 days as compared to the No Action Alternative. The Average Number of Days of Spill per year at Hills Creek is 138 days, Lookout Point is 52 days, and Dexter is 87 days (Appendix D Figure 2-34).

#### *3.5.2.9.5 Coast Fork Dams And Long Tom*

Under Alternative 5 there are no Water Temperature or TDG measures at Cottage Grove, Dorena and Fern Ridge dams, conditions would remain as described in the No Action Alternative and Water Quality Affected Environment.

#### *3.5.2.9.6 Mainstem Willamette River*

**Water Temperature**

Streamflow in Alternative 5 was nearly identical to Alternative 2B and NAA in 2011 and 2016. In 2015, alternative 5 streamflow was generally lower from April to mid-June and higher from mid-June to mid-September compared with NAA (Appendix D Figure 1-376). Streamflow at Salem was generally similar May-September in Alternative 5 compared to Alternative 2B aside from a two-week period in August of 2015, where Alternative 5 resulted in lower streamflow than Alternative 2B. Similar to Alternative 2B, flow differences between Alternative 5 and NAA were primarily in 2015 and responsive to the Measure 30 dam outflow increases in advance of heat wave events (Appendix D Figure 1-376). While temperature simulations are not available for Alternative 5, results would likely be similar to those in Alternative 2B, aside from differences provided in this section (Middle Fork Willamette operation changes in 2015 and 2016) and the two-week period in August of 2015. It is flow changes resulted in warmer water temperatures April to mid-June and cooler water temperatures from mid-June to mid-September compared with NAA in 2015 (Appendix D Figure 1-200, Figure 1-201). Water temperatures at Salem were also affected by upstream dam operations and the proposed SWS-FSS structure at Detroit Dam, which likely contributed to warmer temperatures seen in 2011 and 2015 comparing Alternative 2B to NAA. Overall water temperature differences between Alternative 2B and NAA were less than 2 degrees Celsius.

**TDG**

To the USACE knowledge, there are no TDG gages located on the Willamette River and TDG is presume not to be an issue, as this is a water quality parameter most affected by dam operations. Therefore, TDG gages are typically located downstream of WVS projects where there are known issues.

#### *3.5.2.9.7 Climate Change*

Please reference Technical Appendices B and F for Climate Change qualitative effects closely matched to Alternative 2B. Compared to the No Action Alternative, Alternative 5 would potentially increase resiliency against climate change impacts on water temperature and TDG (increased water temperature control) below Detroit as a result of the proposed SWS and TDG abatement measures at each location.

**Table 3.5-28. Summary of Effects of Alternative 5 as compared to the NAA**

| Subbasin | Alternative 5 |
|---|---|
| North Santiam | Water temperature at Detroit and Big Cliff may have similar effects as Alternative 2B compared to the NAA. A beneficial effect to TDG levels is observed at Detroit and Big Cliff. |

| Subbasin | Alternative 5 |
|---|---|
| South Santiam | Water temperature at Green Peter and Foster may have similar effects as Alternative 2B compared to the NAA. Adverse effects to TDG levels are observed at Green Peter and negligible at Foster. |
| McKenzie | Water temperature at Cougar may have similar effects to as Alternative 2B compared to the NAA. A minor benefit to TDG is observed when at Cougar. Blue River is not expected to change as the RO's are utilized and TDG levels would not be expected to change. |
| Middle Fork Willamette | Water temperature at Lookout Point and Dexter may have similar effects as Alternative 2B compared to the NAA. Minor differences in lake level at Hills Creek may lead to negligible differences in downstream water temperature. Fall Creek temperatures would remain as described in the NAA. A negligible effect is observed for TDG at Hills Creek, Lookout Point, and Dexter dams. |
| Coast Fork Willamette & Long Tom | There are no water temperature measures considered at Cottage Grove, Dorena, and Fern Ridge therefore conditions would remain similar to the NAA. There are no measures considered for TDG management therefore conditions would remain similar to the NAA. |
| Mainstem Willamette | Water temperature at Albany and Salem may have similar effects as Alternative 2B compared to the NAA. Water quality parameters such as TDG, Turbidity, HABs are negligible or have not been reported as a concern. |

*3.5.2.9.8 Evaluation of Near-Term Operations Measure*

See Alternative 2A, Section 3.5.2.4, for description of effects due to the Near-Term Operations Measure.

*3.5.2.9.9 Summary of Effects*

Below is provided a summary of Alternative 5's overall water quality effects.

**Water Temperature**

Alternative 5 is based on Alternative 2B, which had the following measures that affected operations, lake storage, and water temperature: Changes to tributary targets below Foster, Detroit, Lookout Point, and Cougar that are higher than the NAA BiOp targets when those reservoirs are more than 90% full and less than the NAA BiOp when those reservoirs are less than 90% full; Changes to baseline mainstem targets at Salem and Albany while adding a Salem flow target tied to forecasted air temperature; Construct temperature control structure at Detroit; Deep fall drawdown to 35' over the regulating outlet at Green Peter, use of RO in fall, use spillway for surface spill in spring and summer; Deep spring and fall drawdown to 30 feet over the diversion tunnel at Cougar, with a limited refill window between June 15$^{th}$ and November 15$^{th}$ (essentially a delayed refill); Modifications to existing outlets at Foster Dam that would allow releases at varying depths for temperature control by modifying the Facility Warm Water Supply (FWWS) pipe and fish weirs.

RES-SIM simulations of lake levels and dam outflows were used as a basis for assessing the water temperature effects of Alternative 5 in 2011, 2015, and 2016 and are discussed in this section. The underlying assumptions in Alternative 5 were similar to Alternative 2B aside from changes to the spring flow targets at Salem that are lower than BiOp dry year targets in years when water supply forecasted flows at Salem are projected to be less than 25% of normal. This provides additional spring storage in dry years allowing for targets that closely resemble BiOp flow targets to be met in dry summers.

Given the similarities between Alternative 5 and Alternative 2B in the measures, operations, and structural assumptions for Detroit, Green Peter, Foster, and Cougar Dams, it is reasonable to assume any water temperature differences between Alternative 5 and Alternative 2B would be due to model instabilities or processing errors in RES-SIM or CE-QUAL-W2 at those locations. Refer to section Appendix D Section 1.6.4 for details regarding the differences between Alternative 2B and NAA for a description of Alternative 5 water temperature effects. Therefore, this section will focus on the differences in the Middle Fork Willamette, where Minor differences in lake level at Hills Creek may lead to Negligible differences in downstream water temperature.

A full explanation of the RES-SIM analysis and findings can be found in Section 3.2 Hydrologic Processes and Technical Appendix B Hydrology and Hydraulics. Unlike the other alternatives, water temperature simulations were not available in Alternative 5, so a qualitative assessment of potential water temperature downstream of WVS dams is provided in Appendix D Section 1.6.8. Effects are qualitatively described below.

**TDG**

Alternative 5 has no specific measures to reduce TDG. Alternative 5 is based on Alternative 2B, which had the following measures that affected operations total outflow and spill rates that contributes to TDG: Changes to tributary targets below Foster, Detroit, Lookout Point, and Cougar that are higher than the NAA BiOp targets when those reservoirs are more than 90% full and less than the NAA BiOp when those reservoirs are less than 90% full; Changes to baseline mainstem targets at Salem and Albany while adding a Salem flow target tied to forecasted air temperature; Construct temperature control structure at Detroit; Deep fall drawdown to 35' over the regulating outlet at Green Peter, use of RO in fall, use spillway for surface spill in spring and summer; Deep spring and fall drawdown to 30 feet over the diversion tunnel at Cougar, with a limited refill window between June 15$^{th}$ and November 15$^{th}$ (essentially a delayed refill); Modifications to existing outlets at Foster Dam that would allow releases at varying depths for temperature control by modifying the Facility Warm Water Supply (FWWS) pipe and fish weirs.

**Table 3.5-29. Compilation of TDG model results (Appendix D Figures 2-35;2-36;2-34; Figure 3.5-57) downstream of the dams for Alternative 5**

| Location | Average Number of Days Above 110% TDG | Annual Difference in Number of Days Above 110 % TDG compared to the No Action Alternative | Average Number of Days with Spill Per Year | Magnitude of Effects |
|---|---|---|---|---|
| DEX | 20 | 0 | 87 | Negligible |
| LOP | 0 | 0 | 52 | Negligible |
| HCR | 18 | -1 | 138 | Negligible |
| CGR | 13 | -45 | 29 | Minor Benefit |
| FOS | 126 | 94 | 284 | Negligible |
| GPR | 151 | 139 | 190 | Moderate Adverse |
| BCL | 79 | -69 | 86 | Major Benefit |
| DET | 39 | -77 | 62 | Moderate Benefit |

**Turbidity, HABs and Mercury**

Alternative 5 impacts are similar to Alternative 2B for these parameters. Refer to Alternative 2B, Section 3.5.25 for effects as these will not be described further.

## 3.6 VEGETATION

Vegetation is an important element of ecosystems providing environmental functions that are valuable to nearby human communities (e.g., improving water quality, providing shade, and controlling erosion of soils) and providing valuable habitat functions for amphibians, reptiles, birds, invertebrates, fish, and mammals. Plants are considered primary producers in the food web, providing the foundation for other organisms, including humans, and fish and wildlife species, to survive.

### 3.6.1 Affected Environment

Vegetation in the WRB is diverse and vegetative communities are associated with certain habitat types, ranging from alpine meadows and montane forest in the mountains to prairies, oak savannas, and riparian forest on the valley floor.

The area of analysis for vegetation consists of all reservoirs up to the maximum pool elevation and associated aquatic, wetland, riparian, and upland vegetative communities. In addition, the analysis area also includes project stream reaches and associated riparian vegetative communities as listed in Section 3.6.2.

All federal and state listed (listed under the endangered species act) plant species occurring in Oregon are administratively protected by the Oregon Department of Agriculture (ODA). See Section 3.6.1.2 for further detail. Table 3.6-1 shows listing status of special status plants and fungi within the Willamette basin.

#### *3.6.1.1 Existing Vegetation*

Existing vegetation in the analysis area is described here by Environmental Protection Agency (EPA) ecoregions (Thorson et al., 2003). Over the course of several iterations, the EPA worked to divide up the North American continent by different geographic areas and associated ecological communities. Each iteration split these geographic areas and ecological communities up more specifically. EPA Level III ecoregions (a level less specific than Level IV ecoregions) in the Willamette basin include 1, Coast Range; 3, Willamette Valley; and 4, Cascades (Thorson et al., 2003). However, the analysis area does not include the High Cascades or the Coast Range. EPA Level IV ecoregions, which are the most specific ecoregions, include 3b, 3c, 3d, 4a, and 4b within the analysis area. These are described below.

##### *3.6.1.1.1 Ecoregion 3: Willamette Valley*

The Willamette Valley is a wide floodplain valley at about 200 to 500 feet in elevation with fertile soils. These soils derive from deposits from the Missoula floods that took place between 20,000 and 15,000 years ago, when the ice dam that formed glacial Lake Missoula at the end of the last ice age burst repeatedly, resulting in flooding that backed up the Willamette River to present day Eugene, Oregon (Wallick et al., 2013). Historic vegetation in the valley (i.e., pre-European settlement) was a mosaic of gallery forest lining the braided and meandering

Willamette River, wet and upland prairie along the floodplains and terraces, and oak savanna in the foothills. Prairies and oak woodlands likely established during a warm climatic period after the ice age and were maintained by indigenous peoples through prescribed fire until the mid-1800s. The Willamette Valley is densely populated, containing most of Oregon's larger towns and cities surrounded by prime farmland. Consequently, only a remnant of natural vegetation exists today, with less than 2 percent of prairie and less than 1 percent of oak savanna remaining (Christy and Alverson, 2011). Those patches that remain are isolated, threatened by invasive species, and harbor numerous rare and endemic species.

##### *3.6.1.1.2 Ecoregion 3b: Willamette River and Tributaries Gallery Forest*

The Willamette River and Tributaries Gallery Forest hugs the mainstem and tributaries below about 600 feet in elevation. Most of the vegetation analysis area is in this ecoregion. Black cottonwood (*Populus balsamifera*), Oregon ash (*Fraxinus latifolia*), red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), and Douglas-fir (*Pseudotsuga menziesii*) dominate what remains of the forest, with agricultural fields currently the main vegetation type. The main crops along the Willamette mainstem includes grass for seed as well as fruit and nut trees.

The majority of this ecoregion lies within the historic floodplain of the Willamette River, but revetments and reduced flooding following dam construction have reduced the effective floodplain, isolating oxbow lakes and increasing the land area available for farming and towns (Krass et al., 2021). Aquatic vegetation occurs in the Willamette River and tributaries as well as in sloughs and oxbows. Wapato (*Sagittaria latifolia*) is a culturally important species with edible tubers harvested by the Kalapuya peoples and others. Wapato is an aquatic emergent plant found in side channels and slower waters of the Willamette River. Several high priority aquatic invasive species threaten water quality and wapato. These include water primrose (*Ludwigia* spp.) and yellow floating heart (*Nymphoides peltata*) (Krass et al., 2021). Important riparian vegetative communities that include native willows (*Salix* spp.) and black cottonwood are readily established on gravel bars. Changes to these gravel bars associated with channel migration provide the conditions needed for seedling establishment depending on whether there are channel-forming flows (Wallick et al., 2013). Gravel bars also provide ideal conditions for invasion by noxious weeds including butterfly bush (*Buddleia davidii)* and purple loosestrife *(Lythrum salicariae)*.

##### *3.6.1.1.3 Ecoregion 3c: Prairie Terraces*

The Prairie Terraces ecoregion occurs on both sides of the Willamette River and once extended from Eugene to Portland, Oregon as a mosaic of wet and upland prairie supporting a diverse community of plants, animals, and insects. Nearly all of this land now consists of farms or cities, including hundreds of crop species and livestock thriving on the rich soil. Remnant prairie patches harbor numerous ESA-listed plant and animal species (USFWS, 2010). Wet prairies are dominated by tufted hairgrass (*Deschampsia cespitosa*) and support hundreds of other plant species. Sheet flow of water during winter rains occurs at these sites due to an impermeable clay layer formed by ash from the eruption of Mount Mazama, which is now Crater Lake. The recently delisted (86 FR 13200) Bradshaw's desert parsley (*Lomatium bradshawii*) occurs in

Willamette Valley and Southwest Washington wet prairies. Upland prairies were once dominated by short stature native bunch grasses such as California oatgrass (*Danthonia californica*) and Roemer's fescue (*Festuca roemeri*), but these have mostly been replaced with agricultural species including tall fescue (*Schedonorus arundinaceus*), tall oatgrass (*Arrhenatherum elatius*), and creeping bentgrass (*Agrostis stolonifera*). Upland prairies support several ESA-listed plant species, including: the threatened Kincaid's lupine (*Lupinus oreganus*), a host plant for the larva of the endangered Fender's blue butterfly (*Icaricia icarioides fenderi*); the endangered Willamette daisy (*Erigeron decumbens*), which occurs in both wet and upland prairies; and the threatened Nelson's checkermallow (*Sidalcea nelsoniana*) (USFWS, 2010).

##### *3.6.1.1.4 Ecoregion 3d: Valley Foothills*

The Valley Foothills ecoregion occurs around the valley margins and were once dominated by Oregon white oak (*Quercus garryana*) savanna mixed with California black oak (*Quercus kelloggii*) in the south valley and areas including ponderosa pine (*Pinus ponderosa*). Much of this region is now farmed for Christmas trees and wine grapes, and fire suppression has caused the oak savanna to transition to Douglas-fir forest.

##### *3.6.1.1.5 Ecoregion 4a: Western Cascades Lowlands and Valleys*

The Western Cascades Lowlands and Valleys ecoregion occurs in the lower elevations of the western slope of the Cascade Mountains from Eugene to Portland, Oregon below about 3,000 feet in elevation. This region is characterized by heavy rainfall and warm soils and supports a lush mixed conifer forest of western hemlock (*Tsuga heterophylla*) and Douglas-fir, with bigleaf maple and alder in riparian areas. Forest land in this region is a mix of private timber and Bureau of Land Management (BLM) and U.S. Forest Service (USFS) managed lands, with rural communities and farms in the valleys. Special habitats within this region support rare plant species. Some of these include seepy cliffs with Thompson's mistmaiden (*Romanzoffia thompsonii*), riparian forest with tall bugbane (*Cimicifuga elata* var. *elata*), and old growth forest with associated rare lichen and fungi species.

##### *3.6.1.1.6 Ecoregion 4b: Western Cascades Montane Highlands*

The Western Cascades Montane Highlands ecoregion occurs on the western slope of the Cascades above about 3,000 feet in elevation. This region is characterized by a wet climate with heavy winter snowfall. Forests are primarily managed by the USFS and support a mixed conifer forest of Douglas-fir, western hemlock, noble fir (*Abies procera*), and Pacific silver fir (*Abies amabilis*). Cougar, Blue River, and Hills Creek reservoirs occur at the lower elevation range of this region, but the majority of the analysis area here is below 3,000 feet.

##### *3.6.1.1.7 Vegetation in Reservoirs*

Reservoir drawdown zones, areas around the perimeter of the reservoirs where soil saturation is affected by water level fluctuations, create unique ephemeral habitat for plants and animals as well as opportunities for invasive species to rapidly spread and colonize new locations.

USACE manages the water levels in the reservoirs by typically maintaining low water in the winter and re-filling reservoirs in spring, holding water over the summer at full pool. This "backwards" hydrologic regime allows for emergent marsh to form around many reservoirs despite winter drawdowns. In recent years, drought, early draw downs (required by the 2008 Biological Opinion), and summer low water have resulted in reservoirs not filling. This has allowed for establishment of novel communities of drought-tolerant plants. Reed canary grass (*Phalaris arundinacea*) forms extensive monoculture stands covering hundreds of acres, most notably forming a ring around Fern Ridge, but also in shallower upstream portions of most reservoir pools. This species appears to expand occupied areas during low water years.

Common species in reservoir waters include reed canary grass, hardstem bulrush (*Schoenoplectus acutus*), broadleaf cattail (*Typha latifolia*), both native and introduced milfoils (*Myriophyllum* spp.), both native and introduced pondweeds (*Potamogeton* spp.), American waterweed (*Elodia canadensis*), Brazilian waterweed (*Egeria densa*), marsh seedbox (*Ludwigia palustris*), and common bladderwort (*Utricularia vulgaris).* Ephemeral drawdown zone and low water year communities often include beggar-ticks (*Bidens* spp.), cudweeds (*Gnaphalium* spp.), smartweeds (*Persicaria* spp.), spikerushes (*Eleocharis* spp.), and flatsedges (*Cyperus* spp.). Dense beds of aquatic moss (*Fontinalis* sp.) persist. Reservoir margins often support dense thickets of willows, red-osier dogwood (*Cornus stolonifera*), Douglas spirea (*Spirea douglasii*), and black cottonwood. In steeper areas, these species transition immediately to upland vegetation.

Reservoirs host several special status plant species which are listed in Table 3.6-1. Special Status Plant and Fungi Species Occurring in the Analysis Area and described by subbasin in Section 3.6.1.4. Invasive species of concern are listed in Table 3.6-22, and notable species are discussed by subbasin in Section 3.6.1.4.

##### *3.6.1.1.8 2020 Wildfires*

In September of 2020, large catastrophic wildfires altered vegetation and devastated communities in the North Santiam (Beachy Creek Fire) and McKenzie (Holiday Farm Fire) watersheds. These fires burned hot, killing most trees and altering the landscape and vegetation for years to come. Most burned areas were within Ecoregion 4a and included mainly private timber lands and federally managed forests. Salvage logging and hazard tree removal operations are currently in process.

##### *3.6.1.1.9 Historic Vegetation in the Willamette Valley*

Vegetation of Oregon's Willamette Valley has been dramatically altered since the time of pre-Euro-American settlement, approximately 150 years ago. The native plant communities in the valley likely developed at the end of the last ice age and Missoula floods as the climate warmed and prairie plant communities were established. The Willamette Valley is within the traditional territory of the Kalapuya people (Berreman, 1937), and indigenous people managed and maintained the landscape using frequent fires to keep prairies and woodlands open from about 9,300 to 200 B.P. (Walsh et al., 2010). This was most likely done to maintain populations of plants such as camas (*Camassia* spp.), an important starchy tuber and food source, and to open the landscape for hunting. Wapato tubers, which grow in shallow water and thrive in sloughs and oxbows along the Willamette River, were another important food source (Krass et al., 2021).

Beginning in 1850, the General Land Office (GLO) of the U.S. government surveyed land in the west, resulting in the township and range system. These surveys often included information on vegetation, and Christy and Alverson (2011) used these to reconstruct the vegetation of the Willamette Valley at that time. By 1850, only about 4 percent of the valley had been converted to farms, and 1 percent was affected by logging, so this represents a snapshot of the major vegetation types prior to land conversion. This work resulted in a map of the valley showing a riparian corridor (7 percent of analysis area) along the Willamette River, flanked by extensive prairies (31 percent) and savanna (18 percent), with woodlands (13 percent) and upland forest (26 percent) in the foothills (Figure 3.6-1. ).

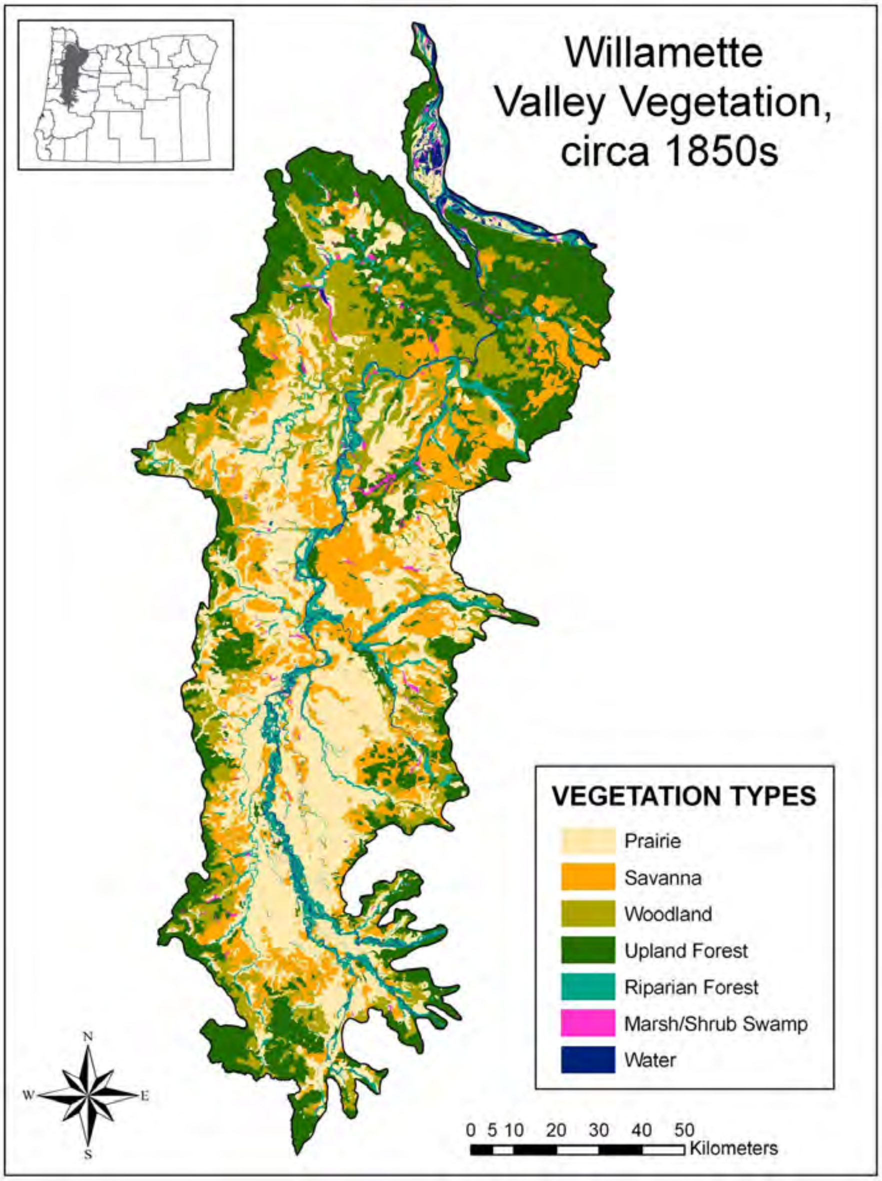



**Figure 3.6-1. Willamette Valley vegetation, circa 1850s.**

Source: Christy and Alverson, 2011

## Table 3.6-1. Special Status Plant and Fungi Species Occurring in the Analysis Area

| Scientific Name | Common Name | Fed ESA[1] | State ESA[1] | ORBIC[2] List | OCS[3] Species | Subbasin[4] NS | SS | MK | MF | CF | LT | MW | Habitat |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Eucephalus vialis* | Bradshaw Wayside aster | - | LT | 1 | yes | - | - | 3 | 1 | 8 | - | - | roadsides, forest edges |
| *Sericocarpus rigidus* | White-topped aster | SOC | LT | 1 | yes | 1 | - | - | - | - | 7 | 1 | wet prairie |
| *Delphinium leucophaeum* | White rock larkspur | SOC | LE | 1 | yes | - | - | - | - | - | - | 6 | forest edges, meadows, riverbanks |
| *Delphinium pavonaceum* | Peacock larkspur | SOC | LE | 1 | yes | - | - | - | - | - | - | 12 | wet prairie, woodland, roadsides |
| *Delphinium oreganum* | Willamette Valley larkspur | SOC | C | 1 | - | 3 | - | - | - | - | 3 | 1 | Oak-ash understory, open areas, roadsides |
| *Horkelia congesta* ssp. *congesta* | Shaggy horkelia | SOC | C | 1 | - | - | - | 1 | - | 3 | 3 | 3 | wet prairie |
| *Sisyrinchium hitchcockii* | Hitchcock's blue-eyed grass | SOC | C | 1 | - | - | - | - | - | 1 | 1 | - | wet and upland prairie |
| *Sullivantia oregana* | Oregon sullivantia | SOC | C | 1 | - | - | - | - | - | - | - | 1 | wet cliffs |
| *Lathyrus holochlorus* | Thin-leaved peavine | SOC | - | 1 | - | 1 | - | - | 3 | 4 | 4 | 12 | oak-ash understory and margins |
| *Howellia aquatilis* | Water howellia | Delisted | LT | 1 | yes | - | - | - | - | - | - | 1 | Aquatic, federally delisted |
| *Lupinus oreganus* | Kincaid's lupine | LT | LT | 1 | yes | - | - | - | - | - | 8 | - | upland prairie |
| *Sidalcea nelsoniana* | Nelson's checkermallow | LT | LT | 1 | yes | 1 | - | - | - | - | - | 2 | upland prairie |
| *Castilleja levisecta* | Golden paintbrush | LT | LE | 1 | yes | - | - | - | - | 1 | 6 | 1 | upland prairie |
| *Erigeron decumbens* | Willamette Valley daisy | LE | LE | 1 | yes | 3 | - | 1 | - | - | 4 | - | wet and upland prairie |
| *Lomatium bradshawii* | Bradshaw's desert parsley | Delisted | LE | 1 | yes | 1 | - | - | - | 2 | 8 | 6 | wet prairie |

| Scientific Name | Common Name | Fed ESA[1] | State ESA[1] | ORBIC[2] List | OCS[3] Species | Subbasin[4] | | | | | | | Habitat |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | NS | SS | MK | MF | CF | LT | MW | |
| *Cimicifuga elata* var. *elata* | Tall bugbane | - | C | 4 | - | - | 2 | 5 | 3 | 1 | - | 8 | riparian understory low elevation |
| *Montia howellii* | Howell's montia | - | C | 4 | - | - | 1 | - | 9 | 4 | 4 | 10 | Moist open places |
| *Sidalcea campestris* | Meadow checkermallow | - | C | 4 | - | 2 | 3 | - | - | - | 1 | 12 | upland prairie |
| *Hypotrachyna riparia* | Lichen | - | - | 1 | - | - | - | 1 | - | 1 | - | - | deciduous shrubs and trees |
| *Navarretia willamettensis* | Willamette navarretia | - | - | 1 | - | - | - | - | - | - | 6 | 1 | wet prairie |
| *Romanzoffia thompsonii* | Thompson's mistmaiden | - | - | 1 | - | - | - | 3 | 2 | - | - | - | very wet cliffs |
| *Sphaerocarpos hians* | Liverwort | - | - | 1 | - | - | - | - | - | - | - | 1 | exposed mud - likely around reservoirs though not documented |
| *Blepharostoma arachnoideum* | Liverwort | - | - | 2 | - | - | - | 2 | - | - | - | - | old growth forests |
| *Bruchia flexuosa* | Bending Bruch's moss | - | - | 2 | - | - | - | - | - | - | 3 | - | wet prairie, mudflats around reservoirs |
| *Carex retrorsa* | Retrorse sedge | - | - | 2 | - | - | - | - | - | - | - | 1 | wet places |
| *Carex scirpoidea ssp. stenochlaena* | Alaskan single spike sedge | - | | 2 | - | - | - | 1 | - | - | - | - | wet cliffs |
| *Cicendia quadrangularis* | Timwort | - | - | 2 | - | - | - | 1 | - | - | 4 | - | wet prairie and seeps |
| *Danthonia spicata* | Poverty oatgrass | - | - | 2 | - | - | 1 | - | - | - | - | 1 | dry, rocky, open |
| *Delphinium nuttallii* | Nuttall's larkspur | - | - | 2 | - | - | - | - | - | 1 | - | - | meadows |
| *Diplacus tricolor* | Three-colored monkeyflower | - | - | 2 | - | - | - | - | - | - | - | 2 | wetlands, riparian |
| *Ephemerum crassinervium* | Emerald dewdrops | - | - | 2 | - | - | - | - | - | - | 3 | - | moist open soil - reservoir edges |

| Scientific Name | Common Name | Fed ESA[1] | State ESA[1] | ORBIC[2] List | OCS[3] Species | Subbasin[4] | | | | | | | Habitat |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | NS | SS | MK | MF | CF | LT | MW | |
| *Ephemerum serratum* | Serrated earth moss | - | - | 2 | - | - | - | - | - | - | 2 | - | moist open soil - reservoir edges |
| *Pannaria rubiginella* | Shingle lichen | - | - | 2 | - | 1 | - | - | - | - | - | - | bark in moist coastal forests |
| *Pellaea andromedifolia* | Coffee fern | - | - | 2 | - | - | - | - | 1 | - | - | - | dry cliffs |
| *Persicaria punctata* | Dotted smartweed | - | - | 2 | - | - | - | - | 1 | - | 2 | - | aquatic |
| *Physcomitrella patens* | Spreading-leaved earth moss | - | - | 2 | - | - | - | - | - | - | - | 1 | lake margins - exposed soil |
| *Pseudocyphellaria mallota* | Lichen | - | - | 2 | - | - | - | 2 | - | - | - | - | on bark in young forests with other cyanolichens |
| *Pyrrocoma racemosa var. racemosa* | clustered goldenweed | - | - | 2 | - | - | - | - | - | - | 5 | - | wet prairie |
| *Rotala ramosior* | Toothcup | - | - | 2 | - | - | - | - | - | - | 1 | 1 | aquatic |
| *Scirpus pallidus* | Pale bulrush | - | - | 2 | - | - | - | - | - | 1 | - | - | riparian |
| *Scirpus pendulus* | Drooping bulrush | - | - | 2 | - | - | 1 | - | 1 | - | - | - | moist areas |
| *Taraxia ovata* | Golden eggs | - | - | 2 | - | - | | - | - | - | - | 1 | open forest understory |
| *Utricularia gibba* | Humped bladderwort | - | - | 2 | - | - | 1 | - | - | - | 1 | - | aquatic |
| *Wolffia borealis* | Dotted water-meal | - | - | 2 | - | - | 1 | - | - | - | - | 2 | aquatic |
| *Wolffia columbiana* | Columbia water-meal | - | - | 2 | - | - | 1 | - | - | - | 1 | 4 | aquatic |
| *Callitriche trochlearis* | Wheel fruited water-starwort | - | - | 2 | - | - | - | - | - | - | - | 1 | aquatic |
| *Potamogeton diversifolius* | waterthread pondweed | - | - | 2 | - | - | - | - | - | - | 3 | - | aquatic - not in ORBIC yet |

Source: ORBIC, 2019

1.ESA = Endangered Species Act, SOC = Species of Concern, LT = Listed as Threatened, LE = Listed as Endangered, C = Candidate

2. ORBIC = Oregon Biodiversity Information Center (ratings explained in Section 3.6.1.2.)

3. OCS = Oregon Conservation Strategy Species

4. NS = North Santiam, SS = South Santiam, MK = McKenzie, MF = Middle Fork, CF = Coast Fork, LT = Long Tom, MW = Mainstem Willamette; numbers shown for each subbasin represent number of observed occurrences of each species.

Note: This table excludes historic and suspected extirpated occurrences. Locations may have been counted in more than one subbasin if near a confluence.

#### *3.6.1.2 **Special Status Plant and Fungi Species***

The U.S. Army Corps of Engineers (USACE) identifies special status species within Operating Projects such as those within the Willamette Valley System (WVS) under Engineering Regulation (ER) 1130-2-540. Special status plant species include those listed by USFWS under the ESA as Threatened, Endangered, Candidate, or Species of Concern (Federally listed); the State of Oregon as Endangered, Threatened, or Candidate (State listed); the Oregon Biodiversity Information Center (ORBIC) as 1 or 2; or Oregon Conservation Strategy (OCS) species. ESA is the regulation that requires Federal and State to protect species and associated habitats. Therefore, the Federal and State governments maintain lists of species that receive protection under the ESA. ORBIC helps protect species and habitats in Oregon by mapping rare species locations and ranking species by their rarity and risk of extirpation. An ORBIC rank of "1" means that the species is considered to be threatened or endangered throughout its range; and an ORBIC rank of "2" means that the species is considered to be threatened, endangered, or extirpated from Oregon, but secure or abundant elsewhere (ORBIC, 2019). OCS species are those that ODFW has determined are of the greatest conservation need in Oregon (ODFW, 2021).

**Error! Reference source not found.**1 lists the sensitive plant and fungi species found in the study area. ORBIC maintains Oregon's geo-database of sensitive species and was used to generate the plant and fungi sensitive species occurrences in **Error! Reference source not found.**1. A selection of all species of plants and fungi occurring within one mile of the project area was created using the following data sources with the ArcGIS select-by-location tool: the WVS project boundaries, the Slices Framework two-year floodplain dataset (Hulse et al., 2002), and Willamette River tributary stream reaches between the 13 dams of the WVS and the mainstem Willamette River (these lines were selected from the National Hydrography Dataset: USGS, 2021). The Slices Framework is a spatially explicit system for tracking changes in the Willamette River and its floodplain used for conservation and restoration planning, accessed through the Oregon Explorer Natural Resources Digital Library. Additional occurrences identified on USACE lands were added by USACE project botanists.

##### *3.6.1.2.1 Focus Special Status Plant Species*

While the survival of most of the species in **Error! Reference source not found.**1 does not rely on the altered hydrologic regime around the dams and reservoirs due to their location in upland habitats, some do. These include aquatic, wetland, and wet prairie species. These are discussed in greater detail by subbasin in Section 3.6.1.4. The following are species that may rely on the current hydrologic regime.

Water howellia (*Howellia aquatilis*) is an aquatic plant that was listed as threatened under the ESA in 1994 and by the State of Oregon. It is also an OCS species. One current occurrence is within the analysis area in a fen along the mainstem Willamette River near Canby, Oregon. Several historic collections were also located along the Willamette River. Habitat for water howellia is restricted to small vernal pools, freshwater wetlands, and old river oxbows with an annual cycle of drying in summer and filling with water in winter. Much of the habitat in Oregon was lost due to land conversion, hydrologic changes after dam construction, and river channelization. Since stable populations exist outside of Oregon, water howellia has been Federally delisted as of July 16, 2021 (86 FR 31955).

Other aquatic species that rely on the current hydrologic regime include three-colored monkeyflower (*Diplacus tricolor*)*,* dotted smartweed *(Persicaria punctata),* toothcup (*Rotala ramosior),* pale bullrush (*Scirpus pallidus),* drooping bullrush (*Scirpus pendulus),* humped bladderwort (*Utricularia gibba),* dotted watermeal (*Wolffia borealis),* Columbia watermeal (*Wolffia columbiana),* wheel fruited water-starwort (*Callitriche trochlearis),* and waterthread pondweed *(Potamogeton diversifolius).* These species are not State or Federally listed, but all are on ORBIC list 2.

Wet prairie habitat is less reliant on the current hydrologic regime, as precipitation is the primary hydrologic driver in these sites. Keeping the water levels low within the reservoirs may alter local hydrology, which may change the wet prairie plant community over time. This scenario most likely is currently occurring at Fern Ridge, where wet prairie (protected as a Research Natural Area) is only a few inches above the elevation of the reservoir when it is full. USACE biologists have observed extremely dry conditions at these sites following two years of low water during the summer as well as a spring drought in 2021. Wet prairie species are noted in **Error! Reference source not found.**1 and include several Federal and State listed species.

Reservoir drawdown zones support a unique ephemeral flora around lake margins. USACE biologists and others (biologists not affiliated with the USACE) have located several sensitive plant species in these areas including Howell's montia (*Montia howellii)*, a State candidate, and several ORBIC list 2 bryophytes including bending Bruch's moss (*Bruchia flexuosa)* and serrated earth moss (*Ephemerum serratum)*.

A few water-loving sensitive plants occur in seeps and wet cliffs along the Willamette River and tributaries. Species include Oregon sullivantia (*Sullivantia oregana),* a Federal and State species of concern, and Thompson's mistmaiden (*Romanzoffia thompsonii)* and Alaskan singlespike sedge (*Carex scirpoidea* ssp. *stenochlaena,* ORBIC list 2).

#### *3.6.1.3 Invasive Plant Species*

Invasive plant species are a major threat to agriculture, native ecosystems, and rare species worldwide. As humans travel and engage in commerce, novel species arrive in new locations. Many of these species are not suited to the new locations, but a few are able to flourish and may outcompete native plant species. The Willamette Valley is hospitable to a wide range of invasive plant species due to a mild climate and a number of introductions that have happened over time. The Oregon Department of Agriculture (ODA) maintains the State noxious weed list and has rated weeds accordingly:

- A-Listed Weed: A weed of known economic importance which occurs in the state in small enough infestations to make eradication or containment possible; or is not known to occur, but its presence in neighboring states make future occurrence in Oregon seem imminent.
- B-Listed Weed: A weed of economic importance which is regionally abundant, but which may have limited distribution in some counties.
- T-Designated Weed: A designated group of weed species that are selected and will be the focus for prevention and control by the Noxious Weed Control Program. Action against these weeds will receive priority. T-designated noxious weeds are determined by the Oregon State Weed Board and directs ODA to develop and implement a statewide management plan. T-designated noxious weeds are species selected from either the A or B list.
- Weed Biological Control (bio): Oregon implements biological control, or "biocontrol" as part of its integrated pest management approach to managing noxious weeds. This is the practice of using host-specific natural enemies such as insects or pathogens to control noxious weeds (ODA, 2020).

The WVS manages weeds using Integrated Pest Management (IPM) as outlined in the ER 1130-2-540, the 2009 USACE Invasive Species Policy (USACE, 2009), and a local Draft IPM plan. Invasive species management with pesticides (including herbicides) also requires compliance with the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and the Clean Water Act National Pollutant Discharge Elimination System (NPDES) Permit for aquatic applications.

#### *3.6.1.3.1 Willamette Invasive Plants*

Invasive plant species listed by ODA and known to occur within one mile of the analysis area are listed in Table 3.6-22 as well as their ODA noxious weed rating and presence regionally and across the WVS. Locations were discovered using a combination of online tools including the ODA Weed Mapper (ODA, 2021) and the OregonFlora Project Mapper (OregonFlora, 2021). Some species may no longer occur in the analysis area due to successful eradication. Invasive plant species of particular concern are discussed by subbasin in the next section.

**Table 3.6-2. Noxious Weeds Occurring in the Vegetation Analysis Area**

| Scientific Name | Common Name | Is it aquatic? | ODA Noxious[1] | Project or Regional Presence |
|---|---|---|---|---|
| *Abutilon theophrasti* | velvetleaf | No | B | Long Tom and Mainstem |
| *Acroptilon repens* | Russian knapweed | No | B, bio | Salem near Santiam, 1 record |
| *Adonis aestivalis* | pheasant's eye | No | B | Eugene and Corvallis - Historic |
| *Ailanthus altissima* | tree of heaven | No | B | Hills Creek fire camp, Mainstem Willamette in Eugene and Portland |
| *Alliaria petiolata* | garlic mustard | No | B, T | Benton County and Portland |
| *Ambrosia artemisiifolia* | ragweed | No | B | Eugene to Columbia River |
| *Amorpha fruticosa* | indigo bush | No | B | Portland |

| Scientific Name | Common Name | Is it aquatic? | ODA Noxious[1] | Project or Regional Presence |
|---|---|---|---|---|
| *Brachypodium sylvaticum* | false-brome | No | B | Ubiquitous |
| *Buddleia davidii* | butterfly bush | No | B | Ubiquitous |
| *Butomus umbellatus* | flowering rush | Aquatic | A | Arlington |
| *Carduus nutans* | musk thistle | No | B, bio | Oakridge, Molalla River |
| *Carduus pycnocephalus* | Italian thistle | No | B | Coast Fork Willamette, Willamette Mainstem |
| *Centaurea calcitrapa* | purple star-thistle | No | A, T | Portland |
| *Centaurea diffusa* | diffuse knapweed | No | B, bio | Lane County |
| *Centaurea jacea notho* subsp. *pratensis* | meadow knapweed | No | B, bio | Ubiquitous |
| *Centaurea stoebe* ssp. *micranthos* | spotted knapweed | No | B, T, bio | Cougar, Hills Creek, Forest Service managed |
| *Centaurea solstitialis* | yellow starthistle | No | B, bio | Lane, once plus 2011 LOP |
| *Chondrilla juncea* | rush skeletonweed | No | B, T, bio | I-5, near LOP |
| *Cirsium arvense* | Canada thistle | No | B, bio | Ubiquitous |
| *Cirsium vulgare* | bull thistle | No | B, bio | Ubiquitous |
| *Clematis vit-alba* | old man's beard | No | B | Coast, Valley |
| *Conium maculatum* | poison hemlock | No | B, bio | Ubiquitous |
| *Convolvulus arvense* | field bindweed | No | B, bio | Ubiquitous |
| *Cynoglossum officinale* | houndstounge | No | B | Near BCL and HCR |
| *Cyperus esculentus* | Yellow nutsedge | No | B | Albany to Confluence |
| *Cytisus scoparius* | Scotch broom | No | B, bio | Ubiquitous |
| *Cytisus striatus* | Portuguese broom | No | B, T | West Eugene and East of Salem |
| *Daphne laureola* | spurge laurel | No | B | CTG, FOS - Menear's Bend |
| *Echium plantagineum* | Paterson's curse | No | A, T | Linn County |
| *Egeria densa* | South American waterweed | Aquatic | B | FRN, mainstem |
| *Euphorbia oblongata* | oblong spurge | No | A, T | FOS - Road Shoulder between Sunnyside and Lewis Parks, Along WR north of Albany |
| *Galega officinalis* | goatsrue | No | A, T | Portland, OR |
| *Genista monspessulana* | French broom | No | B, bio | Lane County |
| *Geranium lucidum* | shining geranium | No | B | Fern Ridge, Dorena, Cottage Grove |
| *Geranium robertianum* | herb robert | No | B | FOS, GPR, Portland |
| *Glyceria declinata* | low mannagrass | Aquatic | - | FRN, Polk County |
| *Hedera helix* | English Ivy | No | B | Ubiquitous |

| Scientific Name | Common Name | Is it aquatic? | ODA Noxious[1] | Project or Regional Presence |
|---|---|---|---|---|
| *Hedera hibernica* | Irish ivy | No | B | ubiquitous: the common ivy in PNW |
| *Heracleum mantegazzianum* | giant hogweed | No | A, T | Oakridge, Eugene, and Portland |
| *Hieracium aurantiacum* | orange hawkweed | No | A, T | 2 Portland records, otherwise not in project area |
| *Hypericum perforatum* | St. John's wort | No | B, bio | Ubiquitous |
| *Impatiens glandulifera* | policeman's helmet | No | B | Portland, OR |
| *Iris pseudacorus* | yellow flag iris | Aquatic | B | Ubiquitous |
| *Lamiastrum galeobdelon* | yellow archangels | No | B | Coast Fork Willamette, Middle Fork Willamette, McKenzie River, FRN, Portland |
| *Lathyrus latifolius* | everlasting peavine | No | B | Ubiquitous |
| *Lepidium chalepense* | lens-podded whitetop | No | B | Corvallis, OR |
| *Lepidium latifolium* | perennial pepperweed | No | B, T | Portland, OR |
| *Linaria dalmatica* | dalmatian toadflax | No | B, T, bio | Portland |
| *Linaria vulgaris* | yellow toadflax | No | B, bio | Mainstem Willamette Eugene to Portland |
| *Ludwigia* spp. | primrose willow | Aquatic | B, T | FRN, Long Tom, Mainstem Willamette to Portland |
| *Lysimachia vulgaris* | garden yellow loosestrife | No | A, T | Willamette River North of Salem |
| *Lythrum salicariae* | purple loosestrife | No | B, bio | FRN, Long Tom, Mainstem Willamette, and North and South Santiam. |
| *Myriophyllum aquaticum* | parrot feather | Aquatic | B | FRN, DOR, Mainstem Willamette |
| *Myriophyllum spicatum* | Eurasian watermilfoil | Aquatic | B | FRN and Mainstem Willamette |
| *Nymphoides peltata* | yellow floatingheart | Aquatic | A | Springfield millrace |
| *Onopordum acanthium* | Scotch thistle | No | B | Ubiquitous |
| *Orobanche minor* | Small broomrape | No | B | Portland |
| *Phragmites australis* ssp. *australis* | common reed | Aquatic | B | Portland |
| *Pilosella cespitosum* | meadow hawkweed | No | B, T | South Santiam and Portland |
| *Fallopia cuspidatum* | giant knotweed | No | B | establishing |
| *Fallopia japonicum* | Japanese knotweed | No | B | establishing |
| *Fallopia sachalinense* | giant knotweed | No | B | establishing |

| Scientific Name | Common Name | Is it aquatic? | ODA Noxious[1] | Project or Regional Presence |
|---|---|---|---|---|
| *Fallopia* X *'bohemicum'* | giant knotweed | No | B | Fern Ridge, Cottage Grove office, Dorena roadsides |
| *Potentilla recta* | sulphur cinquefoil | No | B | Middle Fork Willamette and around Portland |
| *Pueraria lobata* | kudzu | No | A, T | Canby and Portland along Willamette |
| *Ranunculus ficaria* | lesser celandine | No | B | DOR, Middle Fork Willamette, Mainstem, Portland |
| *Rorippa sylvestris* | creeping yellow cress | No | B | Canby and near FRN |
| *Rubus* spp. | introduced blackberries | No | B | Ubiquitous |
| *Sagittaria platyphyla* | delta arrowhead | Aquatic | A, T | Portland |
| *Salvia aethiopsis* | Mediterranean sage | No | B, bio | Near GPR and BCL |
| *Senecio jacobaea* | tansy ragwort | No | B, T, bio | Ubiquitous |
| *Silybum marianum* | milkthistle | No | B, bio | Jasper-Lowell Road and Mainstem Willamette |
| *Solanum rostratum* | bufflaobur | No | B | Portland |
| *Spartium junceum* | Spanish broom | No | B | Near DOR |
| *Taeniatherum caput-medusae* | medusa-head rye | No | B | Ubiquitous |
| *Tribulus terrestris* | puncturevine | No | B, bio | Eugene |
| *Tripidium ravennae* | ravennagrass | No | A, T | Corvallis |
| *Ulex europaeus* | gorse | No | B, T, bio | Powerline near Pleasant Hill |
| *Ventanata dubia* | ventanata grass | No | B | Fern Ridge, DOR, widespread in Willamette Valley |
| *Xanthium spinosum* | spiny cocklebur | No | B | Eugene to Portland |

Source: ODA, 2021

1. For an explanation of the ODA weed ratings see Section 3.6.1.3.

### 3.6.1.4 Subbasin Plant community Descriptions

The WVS consists of seven subbasins: North Santiam, South Santiam, McKenzie, Middle Fork Willamette, Coast Fork Willamette, Long Tom, and Mainstem Willamette. The vegetative communities for each of these subbasins is described in more detail below.

#### *3.6.1.4.1 North Santiam Subbasin*

The North Santiam Subbasin, east of Salem, Oregon is dominated by coniferous forest on steep terrain around Detroit and Big Cliff reservoirs, and grades to flatter farmland and valley floor downstream. The forested lands are in the 4a ecoregion and managed mostly for private timber lands and federally managed forest. Downstream lands grade into ecoregions 3b, 3c, and 3d.

Much of the watershed was burned in the 193,573-acre Beachy Creek Fire and western portion of the Lionshead Fire (204,469 acres) in September 2020. Nearly all of the land surrounding Big

Cliff was burned to the water, and the north side of Detroit and the town of Detroit were also burned. The Beachy Creek Fire burned downstream of Big Cliff to the town of Lyons. Details and maps are available on InciWeb (NWCC, 2021).

No current locations of special status plant or fungi species have been found within a mile of the Detroit or Big Cliff Reservoirs either by USACE biologists or in the 2019 ORBIC database (ORBIC, 2019). Downstream along the North Santiam River, several wet and upland prairie species occur within one mile of the river (see **Error! Reference source not found.**1). A forest with large trees and old growth structure occurs on USFS managed lands along the south side of Detroit Reservoir. Seepy cliffs occurring at both Big Cliff and Detroit reservoirs and likely have not been surveyed for plants.

No noxious weeds of particular concern were identified in the North Santiam subbasin apart from the usual ubiquitous species (see Table 3.6-22).

#### *3.6.1.4.2 South Santiam Subbasin*

The South Santiam Subbasin, east of Albany, Oregon is dominated by coniferous forest on steep terrain around Foster and Green Peter reservoirs, and grades to flatter farmland and valley floor downstream. The forested lands are in the 4a ecoregion and managed mostly for private timber lands and Federally managed forest. Downstream lands grade into ecoregions 3b, 3c, and 3d.

Several special status species occur on USACE lands around Foster and Green Peter reservoirs and downstream. These include tall bugbane, Howell's montia (a State candidate species), and several ORBIC list 2 species (see **Error! Reference source not found.**1). A small pond between Foster Reservoir and N River Road near Lewis Creek Park was found to contain three rare aquatic species, humped bladderwort, dotted watermeal, and Columbia watermeal. The pond is separated from Foster Reservoir. Green Peter Reservoir is mostly surrounded by forest dominated by Douglas-fir. USACE managed lands support stands of big trees with old growth structure and other special habitats.

Invasive plant species Mediterranean sage (*Salvia aethiopsis*), meadow hawkweed (*Pilosella cespitosum*, both are B list weeds), and oblong spurge (*Euphorbia oblongata*, an A list weed) have been found in the South Santiam subbasin but not elsewhere in the Willamette Valley. Equipment cleaning and monitoring could help prevent spread of these and other invasive species.

#### *3.6.1.4.3 McKenzie Subbasin*

Blue River and Cougar reservoirs occur in ecoregions 4a and 4b in the western Cascades. The McKenzie River flows west through forest and small communities, then into the Willamette Valley and the Willamette River near Coburg, Oregon. In September 2020, much of the McKenzie watershed was burned in the 173,393-acre Holiday Farm Fire. Forested areas and vegetation burned to the river in most places from just downstream of the town of McKenzie

Bridge to downstream of Vida, Oregon. Nearly all the land around Blue River Reservoir was burned. Details and maps are available on InciWeb (NWCC, 2021).

Several special status species occur around the reservoirs but are not aquatic species. These are all State candidate and ORBIC list 2 species (see **Error! Reference source not found.**1). Shaddy horkelia *(Horkelia congesta ssp. congesta)*, an SOC and State candidate, and wayside aster (*Eucephalus vialis)*, a Federal SOC and State threatened species, occurring near the confluence with the Willamette River.

No noxious weeds of particular concern were identified in the North Santiam subbasin except the usual ubiquitous species (see Table 3.6-22).

### *3.6.1.4.4 Middle Fork Willamette River Subbasin*

The middle fork of the Willamette River drains a large watershed, and the analysis area includes all previously described ecoregions (3b, 3c, 3d, and 4a). Much of the land around Lookout Point and Hills Creek reservoirs is managed by the USFS, with USACE land and private timber near Fall Creek and Dexter. The towns of Lowell and Dexter are adjacent to Dexter Reservoir, and small farms, prairies, and woodlands occurring downstream. The confluence with the Coast Fork occurs near Mt. Pisgah and is in conservation management by local non-profit groups working to restore flows and native vegetation to old gravel mine sites along with restoration in upland areas.

In terms of special status species, Howell's montia (state candidate) is known to occur in multiple locations around the reservoirs, including a large population found growing on the exposed lakebed at the Hardesty Mountain trailhead during a site visit. This tiny early spring annual plant is likely found in ideal conditions on the exposed mud, but only a few plants were located on a later visit to the same location by USACE biologists. Dotted smartweed occurs in a pond downstream of Hills Creek. Several upland ORBIC list 2 species and tall bugbane occuring around these reservoirs. Special status species habitats in this watershed include oak balds, sunlit canopy openings in mature and old forests, seepy cliffs, and old growth forest in the 4a ecoregion as well as prairies and woodlands downstream.

Invasive species of concern include Sulphur cinquefoil (*Potentilla recta*) and tree of heaven (*Ailanthus altissima*) at Hills Creek, and a report of gorse (*Ulex europaeus*) near Pleasant Hill. Suphur cinquefoil has been found at Lookout Point and Fall Creek as well.

### *3.6.1.4.5 Coast Fork Subbasin*

Cottage Grove and Dorena reservoirs are located at the transition from ecoregion 3 to 4 at the south end of the Willamette Valley within the Coast Fork Subbasin. These reservoirs are surrounded by a combination of upland prairie, woodland, and conifer forest, and USACE lands are surrounded mostly by private farms and timber lands. Downstream the rivers are bordered by forests, farms, and the town of Cottage Grove.

Wayside aster, a Federal SOC and State Threatened species, occurs in several locations near both reservoirs in upland areas. Shaggy horkelia, a Federal SOC and State candidate, occurs near Dorena, above the maximum water surface elevation of the reservoir. Shaggy horkelia also occurs near the confluence of the Row River and Coast Fork Willamette River. Bradshaw's desert parsley (*Lomatium bradshawii,* ESA-delisted in 2019 and State Endangered) occurs nearly a mile from the Coast Fork Willamette in proximity to the confluence of the Coast Fork with the Middle Fork. Thin-leaved peavine (*Lathyrus holochlorus)*, a Federal SOC, occurs in four locations in this watershed mostly near water in forested areas. Several other State candidate and ORBIC list 1 species occuring in this subbasin as well (see **Error! Reference source not found.**1).

No noxious weeds of particular concern were identified in the Coast Fork Subbasin apart from the usual ubiquitous species (see Table 3.6-22).

### *3.6.1.4.6 Long Tom Subbasin*

Fern Ridge Reservoir, the only reservoir located west of the Willamette River, is a wide shallow reservoir on the Long Tom River. Prior to dam construction in 1942, the land consisted mostly of farms, prairies, and gallery forest (i.e., formed as a corridor along a river). Current vegetation surrounding Fern Ridge Reservoir is a mix of ecoregions 3b, 3c, and 3d, with some conifer forest of Douglas-fir and ponderosa pine. The Long Tom River below Fern Ridge dam was channelized by the USACE and is lined by a narrow strip of forest or is immediately adjacent to farmland in places.

Wet and upland prairies in this subbasin support numerous Federally listed and ORBIC listed species, much of which are protected as a Research Natural Area and/or designated critical habitat for Fender's blue butterfly (USFWS, 2010). These sites are located above the maximum water level of the reservoir and are managed in accordance with a Biological Opinion from USFWS (USFWS, 2011). Several ORBIC list 2 aquatic species occuring in these wet and upland prairies (see **Error! Reference source not found.**1).

Invasive primrose willow (*Ludwigia spp.*) has been found in the Long Tom River and has mostly been removed. One small patch was discovered and eradicated in Fern Ridge Reservoir, and surveys have not identified any more. Preventing this species from establishing in Fern Ridge Reservoir is a high priority. Parrot feather (*Myriophyllum aquaticum*), yellow flag iris (*Iris pseudacorus*), South American waterweed (*Egeria densa*), and Eurasian watermilfoil (*Myriophyllum spicatum*) are all common in and around Fern Ridge Reservoir.

### *3.6.1.4.7 Mainstem Willamette River Subbasin*

From the confluence of the Coast and Middle Forks, the Willamette River flows northward through the wide, relatively flat Willamette Valley through major towns and farms to Portland. In many places, narrow strips of gallery forest line the river, while in other locations farms and towns are immediately adjacent to the riverbanks. Parks and conservation areas provide larger forested stretches along with other types of habitats. Numerous old oxbows and sloughs have been isolated from the river but may connect during high flows. These may be sources of invasive species spread but many also contain sensitive species. Wet and upland prairie occuring near the river as well.

Water howellia (a Federally delisted and State threatened species) occurs in a fen near Canby, Oregon just west of the mainstem Willamette River. Other ESA-listed species occurring near the Mainstem Willamette River and within the two-year floodplain, especially in prairies, but with habitat occurring outside of the river channel. Numerous ORBIC list 1 and 2 species occurring along the Willamette River, including many aquatic species (see **Error! Reference source not found.**1).

In terms of invasive plant species occurring within this subbasin, there are many including but not limited to: primrose willow, yellow floating heart, milfoils, and loosestrife occurring in this subbasin (Krass, 2021).

### 3.6.2 Environmental Consequences

This section discusses the potential effects of the alternatives on vegetation. The area of analysis for vegetation consists of all reservoirs up to the maximum pool elevation and associated aquatic, wetland, riparian, and upland vegetative communities. The analysis area also includes the following stream reaches and associated riparian zones:

- Middle Fork Willamette River downstream of Hills Creek Dam to the confluence with the Coast Fork Willamette River;
- Coast Fork Willamette River downstream of Cottage Grove Dam to the confluence with the Middle Fork Willamette River;
- Row River from downstream of Dorena Dam to the confluence with the Coast Fork Willamette River;
- South Fork McKenzie River downstream of Cougar Dam to the confluence with the McKenzie River;
- McKenzie River from the South Fork McKenzie River confluence to the confluence with the Willamette River;
- Blue River downstream of Blue River Dam to the confluence with the McKenzie River;
- Long Tom River downstream of Fern Ridge Dam to the confluence with the Willamette River (includes Coyote Creek from Fern Ridge Dam to the confluence with the Willamette River);
- South Santiam River downstream of Foster Dam to the confluence with the North Santiam River;
- North Santiam River downstream to the confluence with the South Santiam River;
- Santiam River to the confluence with the Willamette River; and
- Willamette River mainstem to Willamette Falls.

For the purpose of more accurately characterizing of the potential occurrence of special status and invasive plant species, a 1-mile buffer surrounding the analysis area was used. The discussion below includes the qualitative methods to evaluate effects to vegetation for each alternative.

### 3.6.3 Methodology

The method used to assess the existing conditions and the alternatives' effects to vegetation was a qualitative analysis based on species presence or absence or suitable habitat present as shown in ORBIC data and direct coordination with USACE biologists in the Willamette Valley who have expertise in both common and rare plant species and conduct routine monitoring of vegetative communities throughout the WVS analysis area. It should be noted that federally ESA-listed plant species would not be affected by any of the alternatives presented in this document because these plants are only located near the analysis area in the vicinity of Fern Ridge. Operations at Fern Ridge would not be modified in any way that would affect these plants for any alternative.

Potential effects to vegetative communities within the WVS analysis area entail indirect effects related to hydrology, sediment transport, erosion, invasive species, and slope failure. Climate change is also anticipated to affect vegetative communities within the WVS over time and is analyzed for each alternative though it is not a result of any of the USACE-proposed alternatives.

Direct effects to vegetation may be included as part of specific construction activities during implementation; however, this PEIS will discuss general qualitative effects from construction at the programmatic level. Site-specific project details for each construction measure will be determined during the implementation phase. Subsequent tiered NEPA documents would discuss detailed site-specific effects during the implementation phase and any applicable permits would be obtained at that time. Direct adverse effects to vegetation associated with construction would include clearing and grubbing for the construction areas or access roads. Following the completion of construction actions that disturb vegetation, areas would be restored with native plants and seed to the extent possible, which would potentially benefit vegetative communities.

The following measures have an effect on vegetation within the WVS analysis area:

- Gravel augmentation below dams (#384);
- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)
- Integrated temperature and habitat flow regime (#30a);
- Refined integrated temperature and habitat flow regime (#30b);
- Augment instream flows by using the inactive pool (#718);
- Reduce minimum flows to Congressionally authorized minimum flow requirements (#723);

- Augment instream flows by using the power pool (#304);
- Deeper fall reservoir drawdowns to fish passage (#40); and
- Spring reservoir drawdown for downstream fish passage (#720).

Measures that would not likely affect vegetation as part of the WVS O&M program include the following: Adapt Hatchery Program (#719), Maintenance of existing and new fish release sites above dams (#726), Construct adult fish facility (#722), Construct water temperature control tower (#105), Use ROs to discharge colder water (#166), Structural improvements to reduce TDG (#174), Foster Fish Ladder Temperature Improvement (#479), Use spillway for surface spill in summer (#721), Construct structural downstream fish passage (#392), Pass water over spillway in spring for fish passage (#714), Provide Pacific lamprey passage and infrastructure (#52), and Restore upstream and downstream passage at drop structures (#639). These measures are not discussed further in regard to effects to vegetation.

**All comparisons of magnitude or duration in the effects analysis for each action alternative are in comparison to the NAA unless stated otherwise.**

**Error! Reference source not found.**3 describes the evaluation criteria for the effect factors (magnitude and duration) and provides a definition for the scale of each effect factor.

**Table 3.6-3. Evaluation Criteria for Potential Effects to Vegetation**

| Effect Scale | Definition |
|---|---|
| **Magnitude** | |
| None/Negligible | Vegetative communities would remain unchanged and no effects would be observable. |
| Minor | Effects to vegetation would be observable (e.g., signs of erosion, changes in vegetation types, sediment deposits over previously vegetated areas) though the effects would be small and localized. |
| Moderate | Effects to vegetative communities would be observable at a regional scale but not be easily measured (e.g., changes to species composition). |
| Major | Effects to vegetation would be readily observable and measurable (e.g., obvious changes in vegetated area and species composition) and would have substantial ecological consequences (e.g., dominance of invasive plant species) at a regional level. Mitigation measures to reduce the adverse effects would be required, though long-term adverse effects to vegetative communities would be expected. |
| **Duration** | |
| Short-term | Disturbance to vegetation would be short in duration, lasting only as long as a discreet construction project or single event in an area. |
| Long-term | Disturbance to vegetation would be ongoing or last beyond operation changes or the completion of a discreet construction project. |

### *3.6.3.1 No Action Alternative*

Vegetation effects associated with the No Action Alternative are related to the current hydrologic regime of the WVS. The current hydrologic regime is the opposite of the natural hydrologic regime. The WSE is the highest within the reservoirs from May through September when the maximum conservation pool is being maintained, whereas naturally this would be the driest time of year within the reservoir area. Summertime reservoir storage has both an adverse and a beneficial effect on vegetation. These effects are minor and long-term. Maximum reservoir storage covers more physical area with water, which means only plant species tolerant of inundation (aquatic plants) can grow in these large areas. The beneficial effect to vegetation associated with maximum summertime reservoir storage is that there is more water available in the soil to support a plant community around the reservoir, which would not be there otherwise because summer precipitation is low throughout the WVS.

Within the WVS, downstream flows are managed so that wintertime flooding, which would naturally occurring without the dams, is mitigated. In addition, revetments within the WVS help ensure that banks are not overtopped in any sort of high flow event. These flood mitigation actions limit the hydrologic connectivity across the floodplains of WVS streams. Therefore, riverine wetlands, off-channel areas, backwater sloughs, and oxbows, that support a diverse plant community, experience drier conditions than they would outside of a managed system and rely more on precipitation than they would otherwise.

#### *3.6.3.1.1 Climate Change*

Climate change is anticipated to lead to wetter winters (increased precipitation) and drier summers (increased temperature and evapotranspiration) which would adversely affect vegetation in the Willamette Valley independent of the WVS operation and maintenance actions over the course of the next 30 years. Effects include increased frequency of wildfires and lower plant survival rates due to drought. A plant community will persist within the WVS analysis area but would likely change in composition with more drought tolerant species becoming increasingly predominant throughout the region. As the plant community changes, invasive plants species are anticipated to move into areas where the native vegetative communities have shrunk. Additionally, climate change is anticipated to continue to increase water temperature over time as air temperatures increase and snowmelt contributes less runoff within the basin. In terms of vegetation, increased water temperatures means a greater frequency of algal blooms, which can adversely affect phytoplankton through shade since phytoplankton are dependent on sunlight for growth. This has ramifications for wildlife species as well which is evaluated in Section 3.9. These vegetation-related climate change effects would be true for the NAA as well as all other alternatives.

### *3.6.3.2 Measures Common to All Action Alternatives*

Measures that are common to all action alternatives that would provide minor long-term benefits to vegetation within the WVS include gravel augmentation below dams (#384) and maintaining or altering revetments (#9).

Gravel augmentation within the Middle Fork Willamette, McKenzie, South Santiam, and North Santiam subbasins is intended to improve instream habitat for ESA-listed UWR Chinook and steelhead as well as other native fish; however, there would be secondary benefits to vegetation. By adding gravel to these streams, there is more potential for sediment transport and accumulation along the stream margins, re-engaging floodplain habitat such as adjacent wetlands, backwater sloughs, and oxbows. In these areas, wetland and riparian vegetation would benefit through improved hydrologic conditions. It should also be noted that engaging more floodplain areas could also have minor long-term effects to riparian vegetation through erosion along the stream banks. However, increasing the hydrologic connectivity across the floodplain and the benefits that has to the vegetative communities outweighs concerns related to potential erosion.

In the same way, maintaining or altering revetments using nature-based engineered techniques is anticipated to improve connections between vegetative communities along the stream margins with the wetland and riparian areas further landward. Currently some of the revetments consist of rock, devoid of vegetation. Converting these to vegetated embankments would allow for better hydrologic connectivity and ecological function along the edges of WVS stream reaches. Using native plant species (e.g., various willows, red osier dogwood, black cottonwood, etc.) as part of the revetment updates and maintenance would increase the seedbank of native plants that can move within the subbasin riparian corridors. Making these improvements would provide moderate long-term benefits for hydrologic connectivity and the native wetland plant community, improving overall wetland condition and ecological function.

#### *3.6.3.3 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

One measure associated with Alternative 1 that would affect vegetation over the NAA, is reducing minimum flows to the Congressionally authorized minimum flow requirements (#723) to benefit reservoir refill objectives within the entire WVS. Therefore, there would be an overall decrease in flows at the North Santiam and South Santiam rivers as well as Fall Creek, which flows into the Middle Fork Willamette. However, the decrease in flow is minor and therefore, long-term hydrologic effects to the vegetative communities along the banks of these streams are anticipated to be negligible. There would also be an increase of downstream flows from the Dexter and Lookout Point dams, which are along the Middle Fork Willamette, which would slightly improve hydrologic conditions for the plant community along the riverbanks. These long-term beneficial effects are also anticipated to be negligible over existing conditions.

In terms of effects to vegetative communities at reservoirs, Alternative 1 also includes augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718), which both result in reservoir drawdowns below the normal rule curve elevations. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Cougar, Green Peter, and Detroit and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows using the inactive pool (#718) is proposed for Fall Creek, Blue River, Cottage Grove, and Dorena. This measure allows the projects to drawdown the pools during the fall.

There is also the potential for minor adverse local effects to wetlands from slope failures along the upstream reservoir rims due to either of these measures as compared to the NAA. If slope failures did occur, there is potential that the landslide debris could bury existing vegetative communities, ultimately causing a short-term loss of vegetated area, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Furthermore, a plant community would re-establish over time but there is potential for this area to re-establish with invasive plant species, which typically proliferate faster than native species.

#### *3.6.3.3.1 Climate Change*

See the NAA for a description of effects due to Climate Change that applies to each action alternative for vegetation. In the case of Alternative 1, augmenting instream flows by using the power pool and the inactive pool would be implemented. However, these do not entail deep drawdowns so these are anticipated to have only minor long-term effects to vegetative communities at the reservoirs (Lookout Point, Hills Creek, Cougar, Green Peter, Detroit, Cottage Grove, Dorena, Fall Creek, and Blue River) that would be compounded by climate change effects. Specifically, a plant community would persist at these reservoirs but would slightly change in composition with more drought tolerant species becoming increasingly predominant throughout the region. Altered hydrology would allow a shift toward more invasive plant assemblages, as non-native species are often more adaptive and resilient and would likely colonize exposed reservoirs more quickly, outcompeting native plants. Ultimately these Alternative 1 effects combined with climate change effects would be anticipated to cause moderate long-term effects to vegetative communities across the WRB.

#### *3.6.3.3.2 Alternative 1 Vegetation Effects Summary Table*

Table 3.6-4 below presents a summary of the effects to vegetation within the WVS as a result of implementation of Alternative 1.

**Table 3.6-4. Summary of effects for vegetation under Alternative 1 as compared to the Alternative 1 – Improve Fish Passage Through Storage-Focused Measures**

| Subbasin | Alternative 1 |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with benefits to riverine vegetative communities<br>North and South Santiam rivers - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Green Peter and Detroit - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Green Peter and Detroit - slope failures with minor adverse localized effects to vegetation |
| Long Tom Subbasin | Negligible change |

| Subbasin | Alternative 1 |
|---|---|
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with benefits to riverine vegetative communities<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Cougar - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Cougar - slope failures with minor adverse localized effects to vegetation |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with benefits to riverine vegetative communities<br>Middle Fork Willamette - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Lookout Point, Hills Creek, and Fall Creek - slope failures with minor adverse localized effects to vegetation |
| Coast Fork of the Willamette Subbasin | Cottage Grove and Dorena – drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Cottage Grove and Dorena - slope failures with minor adverse localized effects to vegetation |
| Mainstem Willamette River | Negligible change |

#### *3.6.3.4 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (includes structural downstream passage at Cougar Dam)*

In terms of effects to vegetation, as a hybrid of the rest of the alternatives, Alternative 2A includes negligible to minor hydrologic impacts to vegetation in the long-term relative to the NAA. Stream flows would be adapted by the integrated temperature and habitat flow regime measure (#30a) which would have negligible effects to streamside wetland and aquatic vegetation within the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins because the hydrological effects that might affect vegetation would be negligible as compared to the NAA.

In terms of effects to vegetative communities at the reservoirs, Alternative 2A also includes augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718), which both result in reservoir drawdowns below the normal rule curve elevations. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Cougar, Green Peter, and Detroit (as in Alternative 1) and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Fall Creek and Blue River and this measure allows the projects to drawdown the pools during the fall. There is also the potential for minor adverse local effects to vegetative communities from slope failures along the upstream reservoir rims due to either of these measures. If slope failures did occur, there is potential that the landslide debris could bury vegetative communities, ultimately causing a short-term loss of vegetated area, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Furthermore, the plant community that is re-established may include invasive plant species, which typically proliferate faster than native species.

In addition, measures that would affect vegetation within the WVS as part of Alternative 2A include a deeper fall reservoir drawdown for fish passage (#40) at Green Peter reservoir (October 15 to December 15). As the reservoir drawdown occurs, the water tables would lower within the wetlands occurring around the reservoir edges and within the reservoir itself. The lowering of the water tables would have hydrological effects to vegetation. As the soils dry up, wetland and aquatic plants that depend on a high water table for survival, would die. In the long term, these areas would not be able to sustain these vegetative communities except the most resilient plants, including invasive plant species as discussed below. The drawdowns would have long-term moderate effects to vegetation surrounding Green Peter reservoir as well as negligible effects to the downstream vegetative communities within the South Santiam subbasin.

In addition, aquatic invasive plant species are known to establish in drawdown zones. The Willamette Aquatic Invasives Network (WAIN) recently published an extensive report on aquatic invasive species in the Willamette River (Krass et al., 2021). This document details processes and types of flows that may cause aquatic invasive plants to thrive or spread. "Scour events during high water can dislodge fragments for further downstream dispersal, flush the area of organic matter, and alter sediment conditions. Conversely, low scour results in increased opportunity for denser plant growth and deeper root establishment that could withstand future high water events." The report focuses primarily on a few high priority invasive plants and details impacts caused by them. High priority aquatic invasive species include *Ludwigia* species, yellow floating heart (currently in the Willamette River), and flowering rush (not found in the Willamette River Basin yet). Medium priority aquatics invasive species include yellow flag iris, narrowleaf cattail, purple loosestrife, tree of heaven, knotweeds, and parrots feather. Ubiquitous aquatic invasive species include reed canary grass, curly leaf pond weed, and Eurasian watermilfoil.

The fall drawdown is likely to allow invasive and versatile species such as but not limited to reed canary grass, yellow flag iris, purple loosestrife, and knotweeds to expand existing populations long-term around Green Peter reservoir as well as downstream through seed or fragment dispersal. These are species that thrive along intermittently inundated areas (e.g., reservoirs). Because of the drawdowns, the time period that portions of the reservoir bed would be exposed and susceptible to invasive species propagation would increase, likely increasing the prevalence of these invasive species around the reservoir (to be transported downstream) long-term. Vegetation monitoring, management, and restoration would need to be incorporated into regular drawdown actions to mitigate moderate effects that could lead to invasive plant population expansion both around the reservoirs and downstream. As the invasive plant population expands, areas that were occupied by native vegetative communities would shrink.

During the first couple years of the fall drawdown, sediment releases are anticipated that could accumulate along downstream stream margins within the South Santiam subbasin, which could temporarily cover vegetative communities in these areas. In addition, it is possible that sediment could be deposited along the downstream channel in such a way that causes erosion in another area adversely affecting nearby vegetative communities primarily along streambanks. When the channel changes shape in an area due to sedimentation, another portion of the channel would potentially be eroded due to stream hydraulics. It should be noted that this sediment is anticipated to be flushed downstream after a couple of years of high flow events that typically occur in the winter and vegetative communities would likely re-establish in these areas. Therefore, only minor short-term effects to vegetation within the South Santiam subbasin are anticipated as a result of sedimentation.

##### *3.6.3.4.1 Near-term Operations Measure*

The overall description of the near-term operations measure can be found within Chapter 2, Section 2.2.5. The analysis of the near-term operations measure effects on vegetation is broken down into subbasins below. This analysis applies to Alternatives 2A, 2B, 3A, 3B, 4, and 5 and this section is referred back to for each Alternative since the near-term operations would be the same for each.

**<u>Santiam Subbasin</u>**

The near-term operations measure within the Santiam subbasin that would affect vegetation indirectly by affecting hydrology and ultimately soil saturation include the following:

- Change in outlet operations at Detroit based on reservoir water surface elevation;
- Fall drawdown at Green Peter and increase in the use of the spillway during the spring; and
- Delayed spring refill and earlier reduction in pool elevation at Foster.

These operational measures would have minor long-term effects to vegetation surrounding Detroit Reservoir because water levels in the reservoir would be lower and would expose more of the reservoir bed. This would affect hydrology and soil saturation that some aquatic and wetland plants around the reservoir depend on for survival. In addition, versatile plants like invasive non-native plants would be more likely to become established and shrink areas occupied by native vegetative communities. The drawdowns are likely to facilitate encroachment of species such as reed canary grass within the reservoir and would increase seed dispersal to downstream areas. To better understand the vegetative response to a change in reservoir elevation, additional monitoring would be needed.

The fish passage operations at Green Peter and Foster would result in lower reservoir levels. These operational measures would have moderate long-term adverse effects to vegetation within aquatic and wetland areas surrounding Green Peter and minor long-term adverse effects to vegetation at Foster reservoir. Aquatic invasive plant species are known to establish in drawdown zones. The drawdowns are likely to facilitate encroachment of invasive plant species such as reed canary grass within the reservoir and would increase seed dispersal to downstream areas. To better understand the vegetative response to a change in reservoir elevation, additional monitoring would be needed.

**Long Tom Subbasin**

There are no local operations proposed under the near-term operations measure within the Long Tom subbasin; therefore, there would be no effects to vegetation as a result of this measure in this subbasin.

**McKenzie Subbasin**

The near-term operations within the McKenzie subbasin that would affect vegetation include the following:

- Delayed spring refill and fall drawdown at Cougar with a downstream flow restriction during some drawdown periods.

These operations have a target elevation of ~1,500 feet and would result in lower reservoir levels throughout the growing season. This operational measure would result in moderate long-term adverse effects to vegetation surrounding the Cougar Reservoir. Like other instances of drawdowns, the effects would entail less hydrology and soil saturation as well as proliferation of invasive non-native plant species within the exposed reservoir bed and within wetland areas around the reservoir. Due to the timing of the drawdowns, exposure of the reservoir bed to invasive plant species would increase. To better understand the vegetative response to a change in reservoir elevation, additional monitoring would be needed.

**Middle Fork Willamette River Subbasin**

The near-term operations within the Middle Fork Willamette subbasin that would affect vegetation include the following:

- Change in outlet operations at Hills Creek based on reservoir water surface elevation;
- Lower spring and summer maximum reservoir elevation at Lookout Point and a fall drawdown, increased use of the spillway based on reservoir water surface elevation; and
- Delayed spring refill from the longer fall drawdown at Fall Creek with step increases in reservoir water surface elevation through the winter.

Similar to other near-term operations measure, the lower reservoir elevations at Lookout Point, Fall Creek, and Hills Creek would result in moderate long-term adverse effects to vegetation surrounding Lookout Point, Fall Creek, and Hills Creek reservoirs. Like other instances of drawdowns, the effects would entail less hydrology and soil saturation as well as proliferation of invasive non-native plant species within the exposed reservoir bed and within wetland areas around the reservoir. Due to the timing of the drawdowns, exposure of the reservoir bed to invasive plant species would increase. To better understand the vegetative response to a change in reservoir elevation, additional monitoring would be needed.

**Coast Fork Subbasin**

There are no local operations proposed under the near-term operations measure within the Coast Fork subbasin, therefore, there would be no effects of this measure to vegetation in this subbasin.

**Mainstem Willamette River**

There are no operations proposed under the near-term operations measure along the Mainstem Willamette River, therefore, no effects of this measure to vegetation are anticipated. There is a slight potential for seed dispersal of invasive plant species occurring downstream of the project subbasins; however, the effects of this along the mainstem would be negligible.

*3.6.3.4.2 Climate Change*

See No Action Alternative, Section 3.6.3.41, for a description of effects due to Climate Change that applies to each action alternative for vegetation. In the case of Alternative 2A, the drawdown at Green Peter reservoir would have moderate long-term effects to vegetative communities at the reservoir and would be compounded by climate change effects. Specifically, a plant community would persist at the reservoir but would likely change in composition with more drought tolerant species becoming increasingly predominant throughout the region. Altered hydrology would allow a shift toward more invasive plant assemblages, as non-native species are often more adaptive and resilient and would likely colonize exposed reservoirs more quickly, outcompeting native plants.

*3.6.3.4.3 Alternative 2A Vegetation Effects Summary Table*

Table 3.6-5 below presents a summary of the effects to vegetation within the WVS as a result of implementation of Alternative 2A.

**Table 3.6-5. Summary of effects for Vegetation under Alternative 2A as compared to the Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (includes structural downstream passage at Cougar Dam)**

| Subbasin | Alternative 2A |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with benefits to riverine vegetative communities |

| Subbasin | Alternative 2A |
|---|---|
| | North and South Santiam rivers - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Green Peter and Detroit - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Green Peter – deep fall season drawdown with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream South Santiam reaches<br>Green Peter and Detroit - slope failures with minor adverse localized effects to vegetation |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with benefits to riverine vegetative communities<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Cougar and Blue River - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Cougar and Blue River - slope failures with minor adverse localized effects to vegetation |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with benefits to riverine vegetative communities<br>Middle Fork Willamette - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Lookout Point, Hills Creek, and Fall Creek - slope failures with minor adverse localized effects to vegetation |
| Coast Fork of the Willamette Subbasin | Negligible change |
| Mainstem Willamette River | Negligible change |

#### *3.6.3.5 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Similar to Alternative 2A, Alternative 2B stream flows would be adapted to fish survival and passage needs which is not anticipated to have a measurable effect to the frequency of inundation and therefore, would have negligible effects to vegetative communities within the downstream aquatic and riparian areas of North Santiam, South Santiam, McKenzie, Coast Fork Willamette, and Middle Fork Willamette subbasins. In terms of effects to vegetative communities at reservoirs, Alternative 2B (similar to Alternative 1 and 2A) includes augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718), which both result in reservoir drawdowns below the normal rule curve elevations. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Cougar, Green Peter, and Detroit (as in Alternatives 1 and 2A) and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Fall Creek and Blue River and this measure allows the projects to drawdown the pools during the fall. There is also the potential for minor adverse local effects to vegetative communities from slope failures along the upstream reservoir rims due to either of these measures. If localized erosion did occur, there is potential that the landslide debris could bury vegetative communities, ultimately causing a short-term loss of vegetated area, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Furthermore, the plant community that is re-established may include invasive plant species, which typically proliferate faster than native species.

The primary difference between Alternatives 2A and 2B is that at the Cougar dam, the diversion tunnel would be used for fish passage for Alternative 2B whereas for Alternative 2A, an FSS would be used. Therefore, the primary difference in effects to wetlands for Alternative 2B as opposed to those stated for Alternative 2A, is effects to vegetation as a result of a spring reservoir drawdown (#720) and a deeper fall reservoir drawdown (#40) at Cougar reservoir (in order to get to the right water surface elevation for the diversion tunnel) in addition to the fall drawdown at Green Peter. The deep spring season drawdown at Cougar would occur May 1 to July 1 and the deep fall season drawdown at Cougar and Green Peter would occur October 15 to December 15. As the reservoir drawdowns occur, the water tables would lower within the wetland and aquatic areas that occur around the reservoir edges. These wetland and aquatic areas would become reliant on precipitation as the primary source of hydrology. During the spring and fall, precipitation is capable of supplementing the water that the vegetative communities in these areas need; however, it is not clear to what extent. The drawdowns would have long-term moderate effects to vegetation surrounding Cougar and Green Peter reservoirs as well as negligible effects to the downstream vegetative communities within the McKenzie and South Santiam subbasins.

The drawdowns are also likely to allow invasive and versatile species such as but not limited to reed canary grass, yellow flag iris, purple loosestrife, and knotweeds to expand existing populations long-term around Cougar and Green Peter reservoir as well as downstream through seed or fragment dispersal, as previously discussed for Alternative 2A in Section 3.6.3.4. These are species that thrive along intermittently inundated areas (e.g., reservoirs). Because of the drawdowns, the time period that portions of the reservoir bed would be exposed and susceptible to invasive species propagation would increase, likely increasing the prevalence of these invasive species around the reservoir (to be transported downstream) long-term. Vegetation monitoring, management, and restoration would need to be incorporated into regular drawdown actions to mitigate moderate effects that could lead to invasive plant population expansion both around the reservoirs and downstream.

In addition to effects to vegetative communities around Cougar and Green Peter reservoirs as a result of the spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40), there could be effects to vegetative communities as a result of slope failure. Cougar reservoir has a mapped ancient landslide along the reservoir rim about 1.3 miles upstream of the dam and Green Peter has a large ancient landslide directly upstream of the dam, although it is difficult to tell from available information whether the landslide is in contact with the reservoir and drawdowns would therefore pose a slope failure risk. If slope failure did occur, there is potential that the landslide debris could bury existing vegetation, ultimately causing a short-term loss of vegetated area, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Furthermore, the plant community that is re-established may include invasive plant species, which typically proliferate faster than native species.

During the first couple years of the spring reservoir drawdowns (#720) and deeper fall reservoir drawdowns (#40) at Cougar and Green Peter, sediment releases are anticipated that could accumulate along downstream stream margins within the South Santiam and McKenzie subbasins, which could temporarily cover vegetative communities in these areas. In addition, it is possible that sediment could be deposited along the downstream channel in such a way that causes erosion in another area adversely affecting nearby vegetative communities primarily along streambanks. It should be noted that this sediment is anticipated to be flushed downstream after a couple of years of high flow events that typically occur in the winter and vegetative communities would likely re-establish in these areas. Therefore, only minor short-term effects to vegetation within the McKenzie and South Santiam subbasins are anticipated as a result of sedimentation.

###### *3.6.3.5.1 Near-term Operations Measure*

See Alternative 2A, Section 3.6.3.4, for a description of effects due to the Near-Term Operations Measure.

###### *3.6.3.5.2 Climate Change*

See No Action Alternative, Section 3.6.3.41, for a description of effects due to Climate Change that applies to each action alternative for vegetation. In the case of Alternative 2B, the drawdowns at Cougar and Green Peter reservoirs would have moderate long-term effects to vegetative communities at the reservoirs and would be compounded by climate change effects. Specifically, a plant community would persist at these reservoirs but would likely change in composition with more drought tolerant species becoming increasingly predominant throughout the region. Altered hydrology would allow a shift toward more invasive plant assemblages, as non-native species are often more adaptive and resilient and would likely colonize exposed reservoirs more quickly, outcompeting native plants.

#### *3.6.3.5.3 Alternative 2B Vegetation Effects Summary Table*

Table 3.6-6 below presents a summary of the effects to vegetation within the WVS as a result of implementation of Alternative 2B.

**Table 3.6-6. Summary of effects for Vegetation under Alternative 2B as compared to the Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative**

| Subbasin | Alternative 2B |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with benefits to riverine vegetative communities<br>North and South Santiam rivers - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Green Peter and Detroit - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Green Peter – deep fall season drawdown with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream South Santiam reaches<br>Green Peter and Detroit - slope failures with minor adverse localized effects to vegetation |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with benefits to riverine vegetative communities<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Cougar and Blue River - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Cougar – deep spring and fall season drawdowns with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream McKenzie reaches<br>Cougar and Blue River - slope failures with minor adverse localized effects to vegetation |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with benefits to riverine vegetative communities<br>Middle Fork Willamette - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Lookout Point, Hills Creek, and Fall Creek - slope failures with minor adverse localized effects to vegetation |

| Subbasin | Alternative 2B |
|---|---|
| Coast Fork of the Willamette Subbasin | Negligible change |
| Mainstem Willamette River | Negligible change |

### 3.6.3.6 Alternative 3A – Improve Fish Passage Through Operations-Focused Measures

Measures that would potentially affect the plant community within the WVS as part of Alternative 3A include integrated temperature and habitat flow regime (#30a), which is not anticipated to have a measurable effect to the frequency of inundation wetland and aquatic areas and therefore would have negligible effects to vegetative communities within the North Santiam, South Santiam, McKenzie, Coast Fork Willamette, and Middle Fork Willamette subbasins.

In terms of effects to vegetative communities at reservoirs, Alternative 3A (similar to Alternatives 1, 2A, and 2B) includes augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718), which both result in reservoir drawdowns below the normal rule curve elevations. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Cougar, Green Peter, and Detroit (as in Alternatives 1, 2A, and 2B) and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Cottage Grove, Dorena, Fall Creek, and Blue River, and this measure allows the projects to drawdown the pools during the fall. There is also the potential for minor adverse local effects to vegetative communities from slope failures along the upstream reservoir rims due to either of these measures. If slope failures did occur, there is potential that the landslide debris could bury vegetative communities, ultimately causing a short-term loss of vegetated area, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Furthermore, the plant community that is re-established may include invasive plant species, which typically proliferate faster than native species.

In addition, a spring reservoir drawdown (#720) at Cougar, Detroit, and Lookout Point reservoirs (May 1 to July 1) and deeper fall reservoir drawdowns (#40) at Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point reservoirs (October 15 to December 15) would occur for fish passage. As the reservoir drawdowns occur, the water tables would lower within the wetland and aquatic areas that occur around the reservoir edges. These wetland and aquatic areas would become reliant on precipitation as the primary source of hydrology. During the spring and fall, precipitation is capable of supplementing the water that the vegetative communities in these areas need; however, it is not clear to what extent. These actions would have long-term moderate effects to vegetation surrounding these reservoirs as well as minor effects to the downstream vegetative communities within the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins and potentially the Willamette River Mainstem.

The spring and fall drawdowns are likely to allow invasive and versatile species such as but not limited to reed canary grass, yellow flag iris, purple loosestrife, and knotweeds to expand existing populations around the reservoirs as well as downstream through seed or fragment dispersal, as previously discussed for Alternative 2A in Section 3.6.3.4. These are species that thrive along intermittently inundated areas (e.g., reservoirs). At Lookout Point, sulfur cinquefoil has been found and may be capable of colonizing the reservoir bed. Because of the drawdowns, the time period that portions of the reservoir bed would be exposed and susceptible to invasive species propagation would increase, likely increasing the prevalence of these invasive species around the reservoir (to be transported downstream). Vegetation monitoring, management, and restoration would need to be incorporated into regular drawdown actions to mitigate moderate effects that could lead to invasive plant population expansion both around the reservoirs and downstream.

In addition to effects to vegetative communities around the reservoirs listed above as a result of the spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40), there could be effects to vegetative communities as a result of slope failure. Cougar reservoir has a mapped ancient landslide along the reservoir rim about 1.3 miles upstream of the dam and Green Peter has a large ancient landslide directly upstream of the dam, although it is difficult to tell from available information whether the landslide is in contact with the reservoir and drawdowns would therefore pose a slope failure risk. If slope failure did occur, there is potential that the landslide debris could bury existing vegetation, ultimately causing a short-term loss of vegetated area, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Furthermore, the plant community that is re-established may include invasive plant species, which typically proliferate faster than native species.

During the first couple years of the spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40), sediment releases are anticipated that could accumulate along downstream stream margins within the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins, which could temporarily cover vegetative communities in these areas. In addition, it is possible that sediment could be deposited along the downstream channel in such a way that causes erosion in another area adversely affecting nearby vegetative communities primarily along streambanks. It should be noted that this sediment is anticipated to be flushed downstream after a couple of years of high flow events that typically occur in the winter and vegetative communities would likely re-establish in these areas. Therefore, only minor short-term effects to vegetation within the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins are anticipated as a result of sedimentation.

###### *3.6.3.6.1 Near-term Operations Measure*

See Alternative 2A, Section 3.6.3.4, for description of effects due to the Near-Term Operations Measure.

#### *3.6.3.6.2 Climate Change*

See No Action Alternative, Section 3.6.3.41, for a description of effects due to Climate Change that applies to each action alternative for vegetation. In the case of Alternative 3A, the drawdowns at Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point reservoirs would have moderate long-term effects to vegetative communities at the reservoirs and would be compounded by climate change effects. Specifically, a plant community would persist at these reservoirs but would likely change in composition with more drought tolerant species becoming increasingly predominant throughout the region. Altered hydrology would allow a shift toward more invasive plant assemblages, as non-native species are often more adaptive and resilient and would likely colonize exposed reservoirs more quickly, outcompeting native plants.

#### *3.6.3.6.3 Alternative 3A Vegetation Effects Summary Table*

Table 3.6-7 below presents a summary of the effects to vegetation within the WVS as a result of implementation of Alternative 3A.

**Table 3.6-7. Summary of effects for Vegetation under Alternative 3A as compared to the Alternative 3A – Improve Fish Passage Through Operations-Focused Measures**

| Subbasin | Alternative 3A |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with benefits to riverine vegetative communities<br>North and South Santiam rivers - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Green Peter and Detroit - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Detroit – fall and spring drawdowns with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream North Santiam and South Santiam reaches<br>Green Peter – deep fall season drawdown with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream Middle Fork Willamette reaches<br>Green Peter and Detroit - slope failures with minor adverse localized effects to vegetation |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with benefits to riverine vegetative communities |

| Subbasin | Alternative 3A |
|---|---|
| | South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Cougar and Blue River - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Cougar – deep spring and fall season drawdowns with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream McKenzie reaches<br>Blue River – deep fall season drawdown with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream McKenzie reaches<br>Cougar and Blue River - slope failures with minor adverse localized effects to vegetation |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with benefits to riverine vegetative communities<br>Middle Fork Willamette - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Lookout Point – deep spring and fall season drawdowns with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream Middle Fork Willamette reaches<br>Hills Creek – deep fall season drawdown with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream Middle Fork Willamette reaches<br>Lookout Point, Hills Creek, and Fall Creek - slope failures with minor adverse localized effects to vegetation |
| Coast Fork of the Willamette Subbasin | Negligible change |
| Mainstem Willamette River | Negligible change |

#### *3.6.3.7 Alternative 3B – Improve Fish Passage Through Operations-Focused Measures using Diversion Tunnel at COU*

In terms of measures that affect vegetation, Alternative 3B is very similar to Alternative 3A. One of the differences is that under Alternative 3B, the spring reservoir drawdown (#720) would occur at Cougar, Green Peter, and Hills Creek reservoirs instead of Cougar, Detroit, and Lookout Point reservoirs. In addition, at Cougar the spring and fall drawdowns would be down to the diversion tunnel to allow for downstream fish passage. Another difference is that augmenting instream flows by using the power pool (#304) would not be implemented at Cougar for Alternative 3B as it had in Alternative 3A. Overall effects for Alterative 3B are characterized in more detail below.

A measure that would potentially affect the plant community within the WVS as part of Alternative 3B include adaptive fish flows (#30a), which is not anticipated to have a measurable effect to the frequency of inundation wetland and aquatic areas and therefore would have negligible effects to vegetative communities within the North Santiam, South Santiam, McKenzie, Coast Fork Willamette, and Middle Fork Willamette subbasins.

In terms of effects to vegetative communities at reservoirs, Alternative 3B includes augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718), which both result in reservoir drawdowns below the normal rule curve elevations. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Green Peter, and Detroit (as in Alternatives 1, 2A, and 2B) and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Cottage Grove, Dorena, Fall Creek, and Blue River, and this measure allows the projects to drawdown the pools during the fall. There is also the potential for minor adverse local effects to vegetative communities from slope failures along the upstream reservoir rims due to either of these measures. If slope failures did occur, there is potential that the landslide debris could bury vegetative communities, ultimately causing a short-term loss of vegetated area, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Furthermore, the plant community that is re-established may include invasive plant species, which typically proliferate faster than native species.

In addition, a spring reservoir drawdown (#720) at Cougar, Green Peter, and Hills Creek Point reservoirs (May 1 to July 1) and deeper fall reservoir drawdowns (#40) at Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point reservoirs (October 15 to December 15) would occur for fish passage. As the reservoir drawdowns occur, the water tables would lower within the wetland and aquatic areas that occur around the reservoir edges. These wetland and aquatic areas would become reliant on precipitation as the primary source of hydrology. During the spring and fall, precipitation is capable of supplementing the water that the vegetative communities in these areas need; however, it is not clear to what extent. These actions would have long-term moderate effects to vegetation surrounding these reservoirs as well as minor effects to the downstream vegetative communities within the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins and potentially the Willamette River Mainstem.

The spring and fall drawdowns are likely to allow invasive and versatile species such as but not limited to reed canary grass, yellow flag iris, purple loosestrife, and knotweeds to expand existing populations around the reservoirs as well as downstream through seed or fragment dispersal, as previously discussed for Alternative 2A in Section 3.6.3.4. These are species that thrive along intermittently inundated areas (e.g., reservoirs). At Lookout Point, sulfur cinquefoil has been found and may be capable of colonizing the reservoir bed. Because of the drawdowns, the time period that portions of the reservoir bed would be exposed and susceptible to invasive species propagation would increase, likely increasing the prevalence of these invasive species around the reservoir (to be transported downstream). Vegetation monitoring, management, and restoration would need to be incorporated into regular drawdown actions to mitigate moderate effects that could lead to invasive plant population expansion both around the reservoirs and downstream.

In addition to effects to vegetative communities around the reservoirs listed above as a result of the spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40), there could be effects to vegetative communities as a result of slope failure. Cougar reservoir has a mapped ancient landslide along the reservoir rim about 1.3 miles upstream of the dam and Green Peter has a large ancient landslide directly upstream of the dam, although it is difficult to tell from available information whether the landslide is in contact with the reservoir and drawdowns would therefore pose a slope failure risk. If slope failure did occur, there is potential that the landslide debris could bury existing vegetation, ultimately causing a short-term loss of vegetated area, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Furthermore, the plant community that is re-established may include invasive plant species, which typically proliferate faster than native species.

During the first couple years of the spring reservoir drawdown (#720) and deeper fall reservoir drawdown (#40), sediment releases are anticipated that could accumulate along downstream stream margins within the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins, which could temporarily cover vegetative communities in these areas. In addition, it is possible that sediment could be deposited along the downstream channel in such a way that causes erosion in another area adversely affecting nearby vegetative communities primarily along streambanks. It should be noted that this sediment is anticipated to be flushed downstream after a couple of years of high flow events that typically occur in the winter and vegetative communities would likely re-establish in these areas. Therefore, only minor short-term effects to vegetation within the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins are anticipated as a result of sedimentation.

##### *3.6.3.7.1 Near-term Operations Measure*

See Alternative 2A, Section 3.6.3.4, for description of effects due to the Near-Term Operations Measure.

##### *3.6.3.7.2 Climate Change*

See No Action Alternative, Section 3.6.3.41, for a description of effects due to Climate Change that applies to each action alternative for vegetation. In the case of Alternative 3B, the drawdowns at Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point reservoirs would have moderate long-term effects to vegetative communities at the reservoirs and would be compounded by climate change effects. Specifically, a plant community would persist at these reservoirs but would likely change in composition with more drought tolerant species becoming increasingly predominant throughout the region. Altered hydrology would allow a shift toward more invasive plant assemblages, as non-native species are often more adaptive and resilient and would likely colonize exposed reservoirs more quickly, outcompeting native plants.

##### *3.6.3.7.3 Alternative 3B Vegetation Effects Summary Table*

Table 3.6-8 below presents a summary of the effects to vegetation within the WVS as a result of implementation of Alternative 3B.

**Table 3.6-8. Summary of effects for Vegetation under Alternative 3B as compared to the Alternative 3B – Improve Fish Passage Through Operations-Focused Measures using Diversion Tunnel at COU**

| **Subbasin** | **Alternative 3B** |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with benefits to riverine vegetative communities<br>North and South Santiam rivers - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Green Peter and Detroit - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Green Peter – deep fall and spring season drawdown with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream South Santiam reaches<br>Detroit – deep fall season drawdown with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream North Santiam reaches<br>Green Peter and Detroit - slope failures with minor adverse localized effects to vegetation |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with benefits to riverine vegetative communities<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Blue River - drawdown with minor hydrological effects to vegetative communities around the reservoirs |

| Subbasin | Alternative 3B |
|---|---|
| | Cougar – deep spring and fall season drawdowns (down to the diversion tunnel) with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream McKenzie reaches<br>Blue River – deep fall season drawdown with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream McKenzie reaches<br>Cougar and Blue River - slope failures with minor adverse localized effects to vegetation |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with benefits to riverine vegetative communities<br>Middle Fork Willamette - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Hills Creek – deep spring and fall season drawdowns with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream Middle Fork Willamette reaches<br>Lookout Point – deep fall season drawdown with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream Middle Fork Willamette reaches<br>Lookout Point, Hills Creek, and Fall Creek - slope failures with minor adverse localized effects to vegetation |
| Coast Fork of the Willamette Subbasin | Cottage Grove and Dorena – drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Cottage Grove and Dorena - slope failures with minor adverse localized effects to vegetation |
| Mainstem Willamette River | Negligible change |

#### *3.6.3.8 Alternative 4 – Improve Fish Passage with Structures-Based Approach*

Effects to vegetation for Alternative 4 would be similar to that of Alternative 1 since these both of these alternatives avoid spring and fall drawdowns and instead utilize structures for water quality and fish passage objectives. This alternative would include: Construct water temperature control towers (#105) at Detroit, Hills Creek, and Lookout Point; Provide Pacific lamprey passage and infrastructure (#52) at Cougar, Dexter, and Hills Creek; restore upstream and downstream passage at drop structures (#639) within the Long Tom River downstream of

Fern Ridge; and construct structural downstream fish passage (#392) at Cougar, Detroit, Foster, Hills Creek, and Lookout Point. Measures included are focused on improving water quality and fish passage.

A measure that would potentially affect the plant community within the WVS as part of Alternative 4 include integrated temperature and habitat flow regime (#30a), which is not anticipated to have a measurable effect to the frequency of inundation wetland and aquatic areas and therefore would have negligible effects to vegetative communities within the North Santiam, South Santiam, McKenzie, Coast Fork Willamette, and Middle Fork Willamette subbasins.

In terms of effects to vegetative communities at reservoirs, Alternative 4 includes augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718), which both result in reservoir drawdowns below the normal rule curve elevations. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Cougar, Green Peter, and Detroit and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Cottage Grove, Dorena, Fall Creek, and Blue River and this measure allows the projects to drawdown the pools during the fall. There is also the potential for minor adverse local effects to vegetative communities from slope failures along the upstream reservoir rims due to either of these measures. If slope failures did occur, there is potential that the landslide debris could bury vegetative communities, ultimately causing a short-term loss of vegetated area, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Furthermore, the plant community that is re-established may include invasive plant species, which typically proliferate faster than native species.

#### *3.6.3.8.1 Near-term Operations Measure*

See Alternative 2A, Section 3.6.3.4, for description of effects due to the Near-Term Operations Measure.

#### *3.6.3.8.2 Climate Change*

See No Action Alternative, Section 3.6.3.41, for a description of effects due to Climate Change that applies to each action alternative for vegetation. In the case of Alternative 4, augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718) would be implemented. However, these do not entail deep drawdowns so these are anticipated to have minor long-term effects to vegetative communities at the reservoirs (Lookout Point, Hills Creek, Cougar, Green Peter, Detroit, Cottage Grove, Dorena, Fall Creek, and Blue River) that would be compounded by climate change effects. Specifically, a plant community would persist at these reservoirs but would slightly change in composition with more drought tolerant species becoming increasingly predominant throughout the region. Altered hydrology would allow a shift toward more invasive plant assemblages, as non-native species are often more adaptive and resilient and would likely colonize exposed reservoirs more quickly, outcompeting native plants. Ultimately these Alternative 4 effects combined with climate change effects would be anticipated to cause moderate long-term effects to vegetative communities across the WRB.

#### *3.6.3.8.3 Alternative 4 Vegetation Effects Summary Table*

Table 3.6-9 below presents a summary of the effects to vegetation within the WVS as a result of implementation of Alternative 4.

**Table 3.6-9. Summary of the effects to vegetation under Alternative 4 as compared to the Alternative 4 – Improve Fish Passage with Structures-Based Approach**

| Subbasin | Alternative 4 |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with benefits to riverine vegetative communities<br>North and South Santiam rivers - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Green Peter and Detroit - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Green Peter and Detroit - slope failures with minor adverse localized effects to vegetation |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with benefits to riverine vegetative communities<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Cougar and Blue River - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Cougar and Blue River - slope failures with minor adverse localized effects to vegetation |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with benefits to riverine vegetative communities<br>Middle Fork Willamette - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor hydrological effects to vegetative communities around the reservoirs |

| Subbasin | Alternative 4 |
|---|---|
| | Lookout Point, Hills Creek, and Fall Creek - slope failures with minor adverse localized effects to vegetation |
| Coast Fork of the Willamette Subbasin | Cottage Grove and Dorena – drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Cottage Grove and Dorena - slope failures with minor adverse localized effects to vegetation |
| Mainstem Willamette River | Negligible change |

#### *3.6.3.9 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 5 is nearly identical to Alternative 2B. However, similar to Alternative 2B, Alternative 5 stream flows would be adapted to fish survival and passage needs except that the integrated temperature and habitat flow regime (#30a, as described in Section 2.3.1.1) has been replaced by the refined integrated temperature and habitat flow regime (#30b as described in Section 2.3.1.2 and Appendix A). Neither of these measures would have a measurable effect to the frequency of inundation and therefore, would have negligible effects to vegetative communities within the downstream aquatic and riparian areas of North Santiam, South Santiam, McKenzie, Coast Fork Willamette, and Middle Fork Willamette subbasins.

In terms of effects to vegetative communities at reservoirs, Alternative 5 (similar to Alternative 1, 2A, and 2B) includes augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718), which both result in reservoir drawdowns below the normal rule curve elevations. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Green Peter, and Detroit and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Fall Creek and Blue River and this measure allows the projects to drawdown the pools during the fall. There is also the potential for minor adverse local effects to vegetative communities from slope failures along the upstream reservoir rims due to either of these measures. If slope failures did occur, there is potential that the landslide debris could bury vegetative communities, ultimately causing a short-term loss of vegetated area, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Furthermore, the plant community that is re-established may include invasive plant species, which typically proliferate faster than native species.

As with Alternative 2B, at the Cougar dam, the diversion tunnel would be used for fish passage for Alternative 5. Therefore, the spring reservoir drawdown (#720) at Cougar would occur May 1 to July 1 and the deeper fall reservoir drawdown (#40) at Cougar and Green Peter would occur October 15 to December 15. As the reservoir drawdowns to the diversion tunnel occur, the water tables would lower within the wetland and aquatic areas that occur around the reservoir edges. These wetland and aquatic areas would become reliant on precipitation as the primary source of hydrology. During the spring and fall, precipitation is capable of supplementing the water that the vegetative communities in these areas need; however, it is not clear to what extent. The drawdowns would have moderate long-term adverse effects to vegetation surrounding Cougar and Green Peter reservoirs as well as negligible effects to the downstream vegetative communities within the McKenzie and South Santiam subbasins.

The drawdowns are also likely to allow invasive and versatile species such as but not limited to reed canary grass, yellow flag iris, purple loosestrife, and knotweeds to expand existing populations long-term around Cougar and Green Peter reservoir as well as downstream through seed or fragment dispersal, as previously discussed for Alternative 2A in Section 3.6.3.4. These are species that thrive along intermittently inundated areas (e.g., reservoirs). Because of the drawdowns, the time period that portions of the reservoir bed would be exposed and susceptible to invasive species propagation would increase, likely increasing the prevalence of these invasive species around the reservoir (to be transported downstream) long-term. Vegetation monitoring, management, and restoration would need to be incorporated into regular drawdown actions to mitigate moderate effects that could lead to invasive plant population expansion both around the reservoirs and downstream.

In addition to effects to vegetative communities around Cougar and Green Peter reservoirs as a result of the spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40), there could be effects to vegetative communities as a result of localized erosion. Cougar reservoir has a mapped ancient landslide along the reservoir rim about 1.3 miles upstream of the dam and Green Peter has a large ancient landslide directly upstream of the dam, although it is difficult to tell from available information whether the landslide is in contact with the reservoir and drawdowns would therefore pose a risk for localized erosion. If localized erosion did occur, there is potential that the debris could bury existing vegetation, ultimately causing a short-term loss of vegetated area, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Furthermore, the plant community that is re-established may include invasive plant species, which typically proliferate faster than native species.

During the first couple years of the spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40) at Cougar and Green Peter, sediment releases are anticipated that could accumulate along downstream stream margins within the South Santiam and McKenzie subbasins, which could temporarily cover vegetative communities in these areas. In addition, it is possible that sediment could be deposited along the downstream channel in such a way that causes erosion in another area adversely affecting nearby vegetative communities primarily along streambanks. It should be noted that this sediment is anticipated to be flushed downstream after a couple of years of high flow events that typically occur in the winter and vegetative communities would likely re-establish in these areas. Therefore, only minor short-term adverse effects to vegetation within the McKenzie and South Santiam subbasins are anticipated as a result of sedimentation.

#### *3.6.3.9.1 Near-term Operations Measure*

See Alternative 2A, Section 3.6.3.4, for a description of effects due to the Near-Term Operations Measure.

#### *3.6.3.9.2 Climate Change*

See No Action Alternative, Section 3.6.3.41, for a description of effects due to Climate Change that applies to each action alternative for vegetation. In the case of Alternative 5, the drawdowns at Cougar and Green Peter reservoirs would have long-term moderate adverse effects to vegetative communities at the reservoirs and would be compounded by climate change effects. Specifically, a plant community would persist at these reservoirs but would likely change in composition with more drought tolerant species becoming increasingly predominant throughout the region. Altered hydrology would allow a shift toward more invasive plant assemblages, as non-native species are often more adaptive and resilient and would likely colonize exposed reservoirs more quickly, outcompeting native plants.

#### *3.6.3.9.3 Alternative 5 Vegetation Effects Summary Table*

Table 3.6-10 below presents a summary of the effects to vegetation within the WVS as a result of implementation of Alternative 5.

**Table 3.6-10. Summary of effects for Vegetation under Alternative 5 as compared to the Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)**

| Subbasin | Alternative 5 |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with benefits to riverine vegetative communities<br>North and South Santiam rivers - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Green Peter and Detroit - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Green Peter – deep fall season drawdown with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream South Santiam reaches<br>Green Peter and Detroit - slope failures with minor adverse localized effects to vegetation |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with benefits to riverine vegetative communities |

| Subbasin | Alternative 5 |
|---|---|
| | South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Blue River - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Cougar – deep spring and fall season drawdowns with long-term moderate effects to vegetation around reservoir and minor short-term effects (sediment) to downstream McKenzie reaches<br>Cougar and Blue River - slope failures with minor adverse localized effects to vegetation |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with benefits to riverine vegetative communities<br>Middle Fork Willamette - minor decreases to downstream flows with negligible hydrological effects to riverine vegetation<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor hydrological effects to vegetative communities around the reservoirs<br>Lookout Point, Hills Creek, and Fall Creek - slope failures with minor adverse localized effects to vegetation |
| Coast Fork of the Willamette Subbasin | Negligible change |
| Mainstem Willamette River | Negligible change |

## 3.7 WETLANDS

Wetlands are important ecosystems providing environmental functions that are valuable to nearby human communities (e.g., improving water quality and flood protection) and providing valuable habitat functions for amphibians, reptiles, birds, invertebrates, fish, and mammals. Wetlands are identified by vegetation type (i.e., hydrophytic vegetation), soil type (i.e., hydric soils), and wetland hydrology (e.g., high water table, soil saturation, etc.). Wetlands are typically found in transitional areas between upland areas (e.g., hillsides) and aquatic areas (e.g., reservoirs).

Within this section, wetlands will be within the context of general habitat classification at the landscape scale. For the affected environment and environmental consequences analysis for specific plant species or assemblages, see Chapter 3.6 Vegetation.

### 3.7.1 Affected Environment

The federal Clean Water Act (CWA) gives the Corps the authority to regulate discharges of pollutants into "Waters of the U.S.," which includes wetlands see Chapter 7 for further information. In Oregon, CWA regulatory authority has also been given to the Oregon Department of Environmental Quality (ODEQ) under Section 401 of the CWA. Within Oregon, the Oregon Department of State Lands has regulatory authority over removal and placement of fill within waters of the State. Wetlands and waterways protected by the CWA are called jurisdictional waters and wetlands. Placing or removing material in wetlands or within waterways may require federal and state permitting.

The WVS area of analysis for wetlands consists of all reservoirs up to the maximum pool elevation (a.k.a., "full pool"), riparian corridors associated with the project stream reaches including around the reservoirs, and the Ordinary High Water Mark (OHWM) along the project stream reaches (listed in 3.7.2). The area of analysis for wetlands was determined because of the following: the maximum pool elevation is the jurisdictional boundary when assessing in-water impacts to reservoirs in Oregon; wetlands within the riparian corridors of the WVS may be hydrologically connected to stream flows within WVS stream reaches as well as reservoirs; and the OHWM is the jurisdictional boundary for streams and rivers.

#### *3.7.1.1 Willamette Valley Wetlands*

Historically, seasonal wetlands were common throughout the Willamette Basin. Roughly 90% of the historic wetlands have been converted to agriculture or other means of development (Oregon Conservation Strategy, 2016). Within the Willamette Basin, wetlands can take many forms including but not limited to backwater sloughs (riverine), oxbow lakes (riverine and palustrine), emergent wetlands (palustrine and riverine), seasonal ponds (palustrine), forested wetlands (palustrine), and wet prairies (palustrine).

For this analysis, the focus are wetlands that may be affected by the WVS. These wetlands include those located along the channels of slow-moving low-gradient stream reaches downstream of the dams, where the floodplain and the channel migration zone broaden. Backwater sloughs and oxbow lakes are formed when a stream channel migrates across the floodplain over time. This process shifts primary stream flows from previously used channels, now backwater sloughs, and completely isolates other portions, which become oxbow lakes. These wetlands are part of the riverine and palustrine systems within the analysis area. In these areas, large floodplain wetland complexes sometimes form over a period of time particularly in lower gradient areas. Vegetation within a backwater slough includes emergent species as well as woody species such as willows (*Salix* spp.), alder (*Alnus rubra*), Oregon ash (*Fraxinus latifolia*), and black cottonwood (*Populus balsamifera*). Backwater sloughs and oxbow lakes provide habitat for various fish, reptiles, amphibians, mammals, and birds. Due to the slower movement of water through backwater sloughs, juvenile salmonids use these areas for rearing and refugia during high water events.

In addition to wetlands located along stream reaches downstream of the dams, wetlands located around or hydrologically connected to the WVS reservoirs, many of which are within the Cascade foothills, are also being considered in this analysis. The reservoirs of the Willamette Basin, operated and maintained by USACE, provide a hydrological regime which results in wetland formation along the edges of the reservoirs despite the lower pool elevations during the winter (see Section 3.6.1.1.7). This hydrologic regime is opposite what would be observed at wetlands around a natural lake. Due to the steep topography of the reservoirs found within the Cascade foothills (see Section 3.6.1.1.5 and 3.6.1.1.6), the formation of these wetlands is generally limited to lower gradient areas near the upstream end of the reservoirs. "Vegetation In Reservoirs" (Section 3.6.1.1.7) provides a list of plants that are associated with these wetlands. The wetlands around the reservoirs provide foraging, breeding, and rearing habitat for numerous species of birds, mammals, reptiles, and amphibians.

All wetland types described in this section are more abundant within the lower elevation reservoirs (Cottage Grove, Dorena, and Fern Ridge) and within the Willamette Valley in areas adjacent to the Mainstem Willamette River and the lower sections of tributaries to the Willamette River.

#### *3.7.1.1.1 National Wetland Inventory (NWI)*

The U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) is a publicly available resource that provides data and mapping on the classification and distribution of wetlands within the U.S. NWI data serves as a planning resource to promote the understanding, conservation, and restoration of wetlands (USFWS, 2021). It is important to note that NWI data is determined through a desktop analysis and therefore this data cannot be used to determine accurate acreage of wetlands within the analysis area.

Within the NWI data, wetlands are classified according to the Cowardin system (1979) into different types based on soil types, hydrologic regime, and vegetation type. The systems of wetland types found within the area of analysis include lacustrine, palustrine, and riverine. Lacustrine wetlands are lakes, reservoirs, or other waterbodies that are situated in a topographic depression or a dammed river channel and are more than 20 acres. Palustrine wetlands include all non-tidal wetlands dominated by trees, shrubs, and persistent emergent vegetation (i.e., plants with their roots underwater but leaves and stems above). Within the area of analysis, palustrine wetlands are located along stream channels. Riverine wetlands are located within the channels of the rivers and streams found throughout the area of analysis. Table 3.7-1 provides summaries of each wetland type included in the subbasin discussion below.

**Table 3.7-1. NWI Wetland Types in the WVS**

| NWI Code | Cowardin Classification | Description |
|---|---|---|
| PEM | Palustrine emergent | Non-tidal wetland dominated by emergent, herbaceous vegetation |
| PSS | Palustrine scrub-shrub | Non-tidal wetland dominated by woody vegetation less than 20 feet tall |
| PFO | Palustrine forested | Non-tidal wetland dominated by woody vegetation 20 feet tall or taller |
| PUB | Palustrine unconsolidated bottom | Non-tidal wetland with 25% or more cover by particles smaller than stones and with less than 30% vegetative cover |
| PAB | Palustrine aquatic bed | Non-tidal wetland dominated by vegetation that grows on or below the surface of the water |
| LUB | Lacustrine unconsolidated bottom | Water body in topographic depression or a dammed river channel, 25% or more cover by particles smaller than stones, with less than 30% vegetative cover |
| RUB | Riverine unconsolidated bottom | A wetland contained within a channel, 25% or more cover by particles smaller than stones, and less than 30% vegetative cover |
| RUS | Riverine unconsolidated shore | A wetland contained within a channel, unconsolidated substrates with less than 75% cover of stones, boulders, or bedrock and less than 30% vegetative cover. |

#### *3.7.1.1.2 North Santiam Subbasin*

According to the NWI data, Big Cliff and Detroit Lake reservoirs are classified as lacustrine unconsolidated bottom (LUB) and include adjacent PEM, PSS, PFO wetlands. Within the analysis area, along the North Santiam River to its confluence with the South Santiam River, riverine unconsolidated bottom (RUB), riverine unconsolidated shore (RUS), palustrine emergent (PEM), palustrine scrub-shrub (PSS), and palustrine forested (PFO) wetlands are located within and alongside the stream channel. This includes some side channels, backwater sloughs, and irrigation ditches. In the vicinity of Stayton Island there is a complex of wetlands within the North Santiam River floodplain that are connected to Wilderness Park and Riverfront Park in Stayton, Oregon. Near the confluence of the North Santiam River with the South Santiam River, there is a large floodplain wetland in the vicinity of Wiseman Island.

#### *3.7.1.1.3 South Santiam Subbasin*

Green Peter Lake and Foster Lake reservoirs are classified as LUB and no adjacent wetlands are shown in the NWI data. South Santiam River downstream of Foster Dam to its confluence with the North Santiam River is classified as RUB and RUS, has PEM, PSS, and PFO wetlands along its edge, and includes side channels, backwater sloughs, and irrigation ditches. There also appears to be a number of nearby ponds, which appear to be gravel pits, classified as palustrine unconsolidated bottom (PUB) along the South Santiam River. Closer to the confluence of the North and South Santiam rivers, there are a number of floodplain wetland complexes according to the NWI data.

#### *3.7.1.1.4 McKenzie Subbasin*

Blue River Lake and Cougar Lake reservoirs are both classified as LUB and do not show adjacent wetlands in the NWI data. The Blue River, South Fork McKenzie River, and McKenzie River are all classified as RUB and RUS and have PEM, PSS, and PFO wetlands along their edges including side channels, oxbows, backwater sloughs, and irrigation canals. Within the mainstem fo the McKenzie River Leaburg Dam and Leaburg Canal provide addition wetland areas along the banks. In the vicinity of Walterville and Springfield, Oregon there are a number of floodplain wetland complexes bisected by the McKenzie River according to the NWI data.

#### *3.7.1.1.5 Middle Fork Willamette River*

Hills Creek Lake, Lookout Point Lake, Dexter Lake, and Fall Creek Lake reservoirs are all classified as LUB and include a couple of adjacent PEM and PSS wetlands according to the NWI data. Downstream of Hills Creek Dam, the Middle Fork Willamette River to its confluence with the Coast Fork Willamette River is RUB and RSC and includes PEM, PSS, and PFO wetlands along it and nearby PUB and palustrine aquatic bed (PAB) wetlands within the floodplain and channel migration zone. There is a smaller floodplain wetland complex just downstream of Dexter Dam as well as a larger floodplain wetland complex with side channels and islands and PEM, PSS, PFO, PUB, PAB, and LUB wetlands located just upstream and at the confluence of the Middle Fork with the Coast Fork south of Springfield, Oregon.

#### *3.7.1.1.6 Coast Fork Willamette River*

According to the NWI data, both Dorena Lake and Cottage Grove Lake reservoirs are LUB and have large PEM wetlands located at their upstream ends. The Row River downstream of Dorena Dam to its confluence with the Coast Fork Willamette River includes many PEM, PSS, PFO wetlands, particularly closer to the confluence. The Coast Fork Willamette River appears to lack wetlands in areas where it is highly channelized with a disconnected floodplain through Cottage Grove, Oregon. But just downstream of its confluence with Row River there are several floodplain wetland complexes and many small PEM, PSS, and PFO wetlands in the surrounding area. In addition, there is large floodplain wetland complex just downstream of Creswell, Oregon with oxbows, backwater sloughs, and side channels.

#### *3.7.1.1.7 Long Tom Subbasin*

The Fern Ridge Lake reservoir is classified as a LUB wetland and is surrounded by a large PEM, PSS, and PFO wetland complex, primarily on the south side. The adjacent PEM wetlands are considered wet prairies and include vegetation specific to Willamette Valley wet prairies described in Section 3.6.4.6. Fern Ridge Lake reservoir has multiple tributaries that feed into it including the Long Tom River, Amazon Canal, and East and West Coyote Creeks. These tributaries are similar in size and wetland complexes associated with them. Directly downstream of Fern Ridge Dam, Kirk Pond, Coyote Creek, and the Long Tom River include both backwater sloughs and oxbow lakes. Many of these habitat types were formed by the Corps of Engineers when the Long Tom River channel was modified in the 1940s. This large wetland complex maintains connections with the Long Tom River via culverts and forms a large wetland complex classified as PFO around the historic channel. Beyond the wetland complex, the Long Tom River (classified as RUB) is highly channelized and there are very few adjacent wetlands shown in the NWI data, though there are some nearby PUB/PEM oxbows and irrigation ditches that flow into the Long Tom. Closer to the Long Tom River's confluence with the Willamette there are a few PEM, PSS, and PFO wetlands.

#### *3.7.1.1.8 Mainstem Willamette River*

Along the Willamette River mainstem downstream to Willamette Falls, there are many types and sizes of wetlands within or along the floodplain. As within other basins, there are a number of off-channel floodplain features such as oxbows, side channels, irrigation ditches, and backwater sloughs. Many of these are associated with river meanders and form large floodplain wetland complexes. There are a number of natural areas that are also associated with these wetland floodplain complexes: Blue Ruin Island, Sam Daw's Landing, Bowers Rock State Park, Luckiamute State Natural Area, Minto-Brown Island Park, Beardsley Bar Landing, Willamette Mission State Park, Grand Island, and Molalla River State Park.

### 3.7.2 Environmental Consequences

This section discusses the potential effects of the alternatives on wetlands. As previously stated, the WVS area of analysis for wetlands consists of all reservoirs up to the maximum pool elevation (a.k.a., "full pool"), riparian corridors associated with the project stream reaches including around the reservoirs, and the Ordinary High Water Mark (OHWM) along the project stream reaches listed below.

- Middle Fork Willamette River downstream of Hills Creek Dam to the confluence with the Coast Fork Willamette River;
- Coast Fork Willamette River downstream of Cottage Grove Dam to the confluence with the Middle Fork Willamette River;
- Row River from downstream of Dorena Dam to the confluence with the Coast Fork Willamette River;

- South Fork McKenzie River downstream of Cougar Dam to the confluence with the McKenzie River;
- McKenzie River from the South Fork McKenzie River confluence to the confluence with the Willamette River;
- Blue River downstream of Blue River Dam to the confluence with the McKenzie River;
- Long Tom River downstream of Fern Ridge Dam to the confluence with the Willamette River (includes Coyote Creek from Fern Ridge Dam to the confluence with the Willamette River);
- South Santiam River downstream of Foster Dam to the confluence with the North Santiam River;
- North Santiam River downstream to the confluence with the South Santiam River;
- Santiam River to the confluence with the Willamette River; and
- Willamette River mainstem to Willamette Falls.

The discussion below includes the qualitative methods used to evaluate wetland effects.

#### *3.7.2.1 Methodology*

The method used to analyze effects to wetlands was qualitative based on potential wetland presence within the WVS analysis area per NWI data and relating that to effects associated with each alternative. Potential effects to wetlands within the WVS analysis area as a result of the alternatives entail indirect effects related to hydrology, sediment transport, erosion, and invasive species. Climate change is also anticipated to affect wetlands within the WVS over time and is analyzed for each alternative though it is not a result of any of the Corps-proposed alternatives.

Direct effects to wetlands may be included as part of specific construction activities during implementation; however, this PEIS will discuss general qualitative effects from construction at the programmatic level. Site-specific project details for each construction measure will be determined during the implementation phase. Subsequent tiered NEPA documents would discuss detailed site-specific effects during the implementation phase. During the planning process for any site-specific project, the Corps would determine whether wetlands are present onsite and, if so, conduct wetland delineations and functional assessments of areas that would be directly affected by construction. The delineations and functional assessments would be used to determine wetland boundaries and the ecological function and value of each wetland affected. Such direct effects could include excavation in wetlands, placing fill in wetlands, impacting wetland vegetation, or altering wetland hydrology. Applicable permits and approvals would be obtained prior to action implementation. In cases of unavoidable impacts to wetlands, the Corps may be required to mitigate for the impacts.

**All comparisons of magnitude or duration in the effects analysis for each action alternative are in comparison to the NAA unless stated otherwise.**

The following measures (described in Chapter 2) have effects on wetlands that will be evaluated in this PEIS:

- Gravel augmentation below dams (#384);
- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9);
- Integrated temperature and habitat flow regime (#30a);
- Refined integrated temperature and habitat flow regime (#30b);
- Augment instream flows by using the inactive pool (#718);
- Reduce minimum flows to Congressionally authorized minimum flow requirements (#723);
- Augment instream flows by using the power pool (#304);
- Deeper fall reservoir drawdowns for fish passage (#40); and
- Spring reservoir drawdown for downstream fish passage (#720).

Measures unlikely to affect wetlands as part of the WVS O&M program or those that would require site-specific considerations beyond the scope of this programmatic document are not discussed further, include the following:

- Adapt hatchery program (#719)
- Maintenance of existing and new fish release sites above dams (#726)
- Construct adult fish facility (#722)
- Construct water temperature control tower (#105)
- Use ROs to discharge colder water (#166)
- Structural improvements for TDG (#174)
- Foster fish ladder temperature improvement (#479)
- Use spillway for summer surface spill (#721)
- Construct structural downstream fish passage (#392)
- Spring spillway fish passage (#714)
- Provide Pacific lamprey passage and infrastructure (#52)
- Restore upstream and downstream passage at drop structures (#639)

Table 3.7-2 describes the evaluation criteria used to determine the magnitude and duration of effects.

**Table 3.7-2. Evaluation Criteria for Potential Effects to Wetlands**

| Effect Scale | Definition |
|---|---|
| **Magnitude** | |
| None/negligible | Wetlands would not be affected and no effects would be observable. |
| Minor | Effects to wetlands would be observable (e.g., signs of erosion, changes in vegetation types, sediment deposits) though the effects would be small and localized. |
| Moderate | Effects to wetlands would be observable at a regional scale but not be easily measured (e.g., changes to wetland acreage). |
| Major | Effects to wetlands would be readily observable and measurable (e.g., obvious changes in wetland acreage) and would have substantial ecological consequences (e.g., loss of wetland habitat for special status species) at a regional level. Mitigation measures to reduce the adverse effects would be required, though long-term adverse effects to wetlands would be expected. |
| **Duration** | |
| Short-term | Disturbance to wetlands would be short in duration, lasting only as long as a discreet construction project or single event in an area (e.g., construction access over a wetland using minimization measures). |
| Long-term | Disturbance to wetlands would ongoing or last beyond operation changes or the completion of construction projects. |

#### *3.7.2.2 No Action Alternative*

Wetland effects associated with the No Action Alternative are related to the current hydrologic regime of the WVS. The current hydrologic regime is the opposite of the natural hydrologic regime. The WSE is the highest within the reservoirs from May through September when the maximum conservation pool is being maintained, whereas naturally this would be the driest time of year within the reservoir area. This condition creates and maintains wetlands along the edge of full-pool elevation within the reservoirs even when precipitation is at its lowest annual levels. The No Action Alternative would continue to support these wetlands, resulting in no or negligible effect.

Within the WVS, downstream flows are managed so that wintertime flooding, which would naturally occur without the dams, is mitigated. In addition, revetments within the WVS help ensure that banks are not undercut or overtopped in any sort of high flow event. These flood mitigation actions limit the hydrologic connectivity across the floodplains of WVS streams. Therefore, riverine wetlands experience drier conditions than they would outside of a managed system and rely more on precipitation than they would otherwise. Under the No Action Alternative, flow management would not change and these conditions would remain the same. Thus, the effect would be none/negligible.

Climate change is anticipated to lead to wetter winters (increased temperature and precipitation) and longer drier summers (increased temperature and evapotranspiration) which would adversely affect wetlands in the Willamette Valley independent of the WVS operation and maintenance actions over the course of the next 30 years. Having drier summers is anticipated have moderate long-term adverse effects to wetlands within the WVS analysis area. Wetland soils and wetland vegetative communities are largely dependent on wetland hydrology as a result of a high water table, precipitation, and overland flows primarily. With longer drier summers, wetland hydroperiods (how long wetlands are inundated or wetland soils are saturated) would change for some wetlands which would change the wetland plant community. In addition, wetland area within the WVS analysis area may shrink which would adversely affect a number of other resources such as water quality, fish and wildlife, and vegetation. As native wetland vegetative communities shrink, invasive plant species would thrive, which would ultimately have adverse effects to the ecological functions of the wetlands that do remain. These wetland-related climate change effects are anticipated for the NAA as well as all other alternatives.

#### *3.7.2.3 Measures Common to All Action Alternatives*

Measures that are common to all action alternatives that would provide minor benefits to wetlands within the WVS include gravel augmentation below dams (#384) and maintaining or altering revetments (#9).

Gravel augmentation below dams within the Middle Fork Willamette, McKenzie, South Santiam, and North Santiam subbasins is intended to improve instream habitat for ESA-listed UWR Chinook and steelhead as well as other native fish; however, there would be secondary benefits to wetlands. By adding gravel to these streams, there is more potential for sediment transport and accumulation along the stream margins, re-engaging floodplain areas. These areas often contain wetlands and with better hydrologic connectivity within the floodplain, wetland hydrology would be better supported (i.e., more regular inundation and soil saturation). Therefore, adding gravel and re-engaging floodplain areas is anticipated to provide long-term benefits to wetlands along the WVS stream reaches downstream of the dams. It should also be noted that engaging more floodplain areas could also have minor long-term effects to wetlands through erosion. However, increasing the hydrologic connectivity across the floodplain and the benefits that has to wetlands outweighs concerns related to potential erosion.

In the same way, maintaining revetments using bio-engineered techniques is anticipated to improve vegetative communities along the stream margins within the wetland and riparian areas further landward. Currently some of the revetments consist of rock, devoid of vegetation. Converting these to vegetated embankments would allow for better hydrologic connectivity and ecological function along the edges of WVS stream reaches. Using native plant species (e.g., various willows, red osier dogwood, black cottonwood, etc.) as part of the revetment updates and maintenance would increase the seedbank of native wet-tolerant plants that can move within the subbasin and propagate within streamside wetlands. Making these improvements would provide moderate long-term benefits for wetland hydrologic connectivity and the native wetland plant community, improving overall wetland condition and ecological function.

#### *3.7.2.4 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

One measure associated with Alternative 1 that would affect wetlands compared to the NAA, is reducing minimum flows to the Congressionally authorized minimum flow requirements (#723) to benefit reservoir refill objectives within the entire WVS. In Alternative 1, there would be an overall decrease in flows at the North Santiam and South Santiam rivers as well as Fall Creek, which flows into the Middle Fork Willamette. However, these decreases in flow are minor and therefore, hydrologic effects to the PEM/PSS/PFO wetlands along these streams are anticipated to be negligible. There would also be an increase of downstream flows from the Dexter and Lookout Point dams, which are along the Middle Fork Willamette, which would slightly improve hydrologic conditions for the streamside PEM/PSS/PFO wetlands. Generally, more flow in stream channels benefits wetlands within or next to the channels by increasing the water table within these areas. However, these flow increases are so slight, that these beneficial effects are anticipated to be negligible over existing conditions.

In terms of effects to wetlands around reservoirs, Alternative 1 also includes augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718), which both result in reservoir drawdowns below the normal rule curve elevations. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Cougar, Green Peter, and Detroit and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Fall Creek, Blue River, Cottage Grove, and Dorena. This measure allows the projects to drawdown the pools during the fall. There is also the potential for minor, adverse, local effects to wetlands from localized erosion along the upstream reservoir rims due to either of these measures. If localized erosion did occur, there is potential that the debris could bury existing wetlands, ultimately causing a long-term loss of wetland function and acreage, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Because wetland surveys specific to these areas have not been conducted to date, it is impossible to quantify the wetland acreage that could be affected.

##### *3.7.2.4.1 Climate Change*

See the NAA for a description of effects due to Climate Change that applies to each action alternative for wetlands. Alternative 1 maximizes storage within the reservoirs and effects of downstream flows would be anticipated to be negligible. Climate change is anticipated to cause moderate long-term effects to wetlands within the WRB, which would not be affected by Alternative 1 measures.

#### *3.7.2.4.2 Alternative 1 Wetlands Effects Summary Table*

Table 3.7-3 below presents a summary of the effects to wetlands within the WVS as a result of implementation of Alternative 1.

**Table 3.7-3. Summary of Effects for Wetlands Under Alternative 1 as Compared to the Alternative 1 – Improve Fish Passage Through Storage-Focused Measures**

| Subbasin | Alternative 1 |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with long-term benefits to streamside wetlands<br>North and South Santiam rivers - minor decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Green Peter and Detroit - drawdowns with minor long-term effects to wetlands around the reservoirs<br>Green Peter and Detroit – localized erosion with minor short-term adverse effects to wetlands |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with long-term benefits to streamside wetlands<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Cougar and Blue River - drawdowns with minor long-term effects to wetlands around the reservoirs<br>Cougar - localized erosion with minor short-term adverse effects to wetlands |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with long-term benefits to streamside wetlands<br>Middle Fork Willamette - minor decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor long-term effects to wetlands around the reservoirs<br>Lookout Point, Hills Creek, and Fall Creek - localized erosion with minor short-term adverse localized effects to wetlands |
| Coast Fork of the Willamette Subbasin | Cottage Grove and Dorena – drawdowns with minor long-term effects to wetlands around the reservoirs<br>Cottage Grove and Dorena - localized erosion with minor short-term adverse effects to wetlands |
| Mainstem Willamette River | Negligible change |

### 3.7.2.5 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (includes structural downstream passage at Cougar Dam)

For Alternative 2A stream flows will be the integrated temperature and habitat flow regime (#30a), which is not anticipated to have a measurable effect to the frequency of inundation and therefore would have negligible effects to PEM/PSS/PFO wetlands within the North Santiam, South Santiam, McKenzie, Coast Fork Willamette, and Middle Fork Willamette subbasins.

In terms of effects to wetlands around reservoirs, Alternative 2A also includes augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718), which both result in reservoir drawdowns below the normal rule curve elevations. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Cougar, Green Peter, and Detroit (as in Alternative 1) and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Fall Creek and Blue River and this measure allows the projects to drawdown the pools during the fall. As these drawdowns occur, the water table that provides hydrology to the wetlands around the reservoirs would drop. As the water table drops, wetlands would change in character (e.g, loss of wetland plants and soil moisture) and be less likely to provide ecological functions (e.g., water quality, wildlife habitat, biodiversity) over time. There is also the potential for minor, adverse, local effects to wetlands localized erosion along the upstream reservoir rims due to either of these measures. If erosion did occur, there is potential that the sediment could bury existing wetlands, ultimately causing a long-term loss of wetland function and acreage, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Because wetland surveys specific to these areas have not been conducted to date, it is impossible to quantify the wetland acreage that could be affected.

In addition, measures that would affect wetlands within the WVS as part of Alternative 2A include deeper fall season drawdowns (#40) at Green Peter reservoir (October 15 to December 15) for fish passage. As the reservoir drawdown occurs, the water tables would lower within the wetlands that occur around the reservoir edges. These wetlands would become reliant on precipitation as the primary source of hydrology during this period. During the fall, precipitation is capable of supplementing the water that these wetlands need; however, it is not clear to what extent. The fall drawdown at Green Peter is anticipated to cause moderate observable effects (e.g., dead or dying wetland plants) to wetlands around the reservoir.

In addition to changes to the water tables in wetlands around Green Peter reservoir as a result of the deeper fall reservoir drawdowns (Measures #40), there could be effects to wetlands as a result of localized erosion. Green Peter reservoir has a large ancient landslide directly upstream of the dam, although it is difficult to tell from available information whether the landslide is in contact with the reservoir and drawdowns would therefore pose a risk of localized erosion. If localized erosion did occur, there is potential that the landslide debris could bury existing wetlands, ultimately causing a long-term loss of wetland function and acreage, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Because wetland surveys specific to these areas have not been conducted to date, it is impossible to quantify the wetland acreage that could be affected.

During the first couple years of the fall drawdown, sediment releases are anticipated that could accumulate along downstream stream margins within the South Santiam subbasin, affecting the hydrologic connectivity between the active channels and streamside PEM/PSS/PFO wetlands. The sediment transported downstream could be deposited so that a wetland is further removed from the stream channel and is therefore less likely to be influenced by the flow within the active channel. Another possibility is that sediment could be deposited along the downstream channel in such a way that causes erosion of a nearby wetland as the streamflow adjusts around the deposited material. It should be noted that this sediment is anticipated to be flushed downstream after a couple of years of high flow events that typically occur in the winter and therefore, only a negligible short-term effect is anticipated.

##### *3.7.2.5.1 Near-term Operations Measure*

The description of the near-term operations measure can be found within Chapter 2, Section 2.2.5. The analysis of the near-term operations measure effects on wetlands is broken down into subbasins below. This analysis applies to Alternatives 2A, 2B, 3A, 3B, 4, and 5 and this section is referred back to for each Alternative since the near-term operations would be the same for each.

**Santiam Subbasin**

The near-term operations measure within the Santiam subbasin that would affect wetlands indirectly by affecting hydrology and ultimately soil saturation and wetland plant survival include the following:

- Change in outlet operations at Detroit based on reservoir water surface elevation;
- Fall drawdown at Green Peter and increase in the use of the spillway during the spring; and
- Delayed spring refill and earlier reduction in pool elevation at Foster.

These operational measures would have minor long-term effects to vegetation surrounding Detroit Reservoir because water levels in the reservoir would be lower and would expose more of the reservoir bed. This would affect hydrology and soil saturation that support wetland soils and wetland plants around the reservoir.

The fish passage operations at Green Peter and Foster would result in lower reservoir levels. As the reservoir levels lower, the water tables would lower within the wetlands that occur around the reservoir edges. These wetlands would become reliant on precipitation as the primary source of hydrology. During the spring and fall, precipitation is capable of supplementing wetland hydrology within these wetlands; however, it is not clear to what extent. These operational measures would have moderate long-term adverse effects to wetlands surrounding

Green Peter within aquatic and wetland areas and minor long-term adverse effects to wetlands at Foster reservoirs.

**Long Tom Subbasin**

There are no local operations proposed under the near-term operations measure within the Long Tom subbasin, therefore, there would be no effects of this measure to wetlands in this subbasin.

**McKenzie Subbasin**

The near-term operations within the McKenzie subbasin that would affect wetlands include the following:

- Delayed spring refill and fall drawdown at Cougar with a downstream flow restriction during some drawdown periods.

These operations have a target elevation of ~1,500 feet and would result in lower reservoir levels throughout the growing season. This operational measure would result in moderate, long-term, adverse effects to wetlands surrounding the Cougar Reservoir. As the reservoir levels lower, the water tables would lower within the wetlands that occur around the reservoir edges. These wetlands would become reliant on precipitation as the primary source of hydrology. During the spring and fall, precipitation is capable of supplementing wetland hydrology within these wetlands; however, it is not clear to what extent.

**Middle Fork Willamette River Subbasin**

The near-term operations within the Middle Fork Willamette subbasin that would affect wetlands include the following:

- Change in outlet operations at Hills Creek based on reservoir water surface elevation;
- Lower spring and summer maximum reservoir elevation at Lookout Point and a fall drawdown, increased use of the spillway based on reservoir water surface elevation; and
- Delayed spring refill from the longer fall drawdown at Fall Creek with step increases in reservoir water surface elevation through the winter.

Similar to other near-term operations, the lower reservoir levels at Lookout Point, Fall Creek, and Hills Creek would result in moderate long-term adverse effects to wetlands around the reservoirs. As the reservoir levels lower, the water tables would lower within the wetlands that occur around the reservoir edges. These wetlands would become reliant on precipitation as the primary source of hydrology. During the spring and fall, precipitation is capable of supplementing wetland hydrology within these wetlands; however, it is not clear to what extent.

**Coast Fork Subbasin**

There are no local operations proposed under the near-term operations measure within the Coast Fork subbasin, therefore, there would be no effects of this measure to wetlands in this subbasin.

**Mainstem Willamette River**

No effects to wetlands along the Mainstem Willamette River are anticipated as a result of the near-term operations measure.

*3.7.2.5.2 Climate Change*

See No Action Alternative, Section 3.7.2.2., for a description of effects due to Climate Change that applies to each action alternative for wetlands. In the case of Alternative 2A, the fall drawdown at Green Peter is anticipated to cause minor observable effects to wetlands around the reservoir, but this would be compounded by climate change effects which are anticipated to cause long-term, moderate, and observable (at the regional scale) effects to wetlands throughout the WVS. Therefore, it is possible that the effects of the deep drawdown combined with the effects of climate change could cause major effects to wetlands at Green Peter reservoir, including loss of wetland acreage and ecological functions specific to wetlands. It is worth noting that because on-the-ground wetland surveys have not been conducted, it is unclear how many wetlands and how large an area would be affected.

*3.7.2.5.3 Alternative 2A Wetlands Effects Summary Table*

Table 3.7-4 below presents a summary of the effects to wetlands within the WVS as a result of implementation of Alternative 2A.

**Table 3.7-4. Summary of Effects for Wetlands under Alternative 2A as Compared to the Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (includes structural downstream passage at Cougar Dam)**

| Subbasin | Alternative 2A |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with long-term benefits to streamside wetlands<br>North and South Santiam rivers - minor decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Green Peter and Detroit - drawdowns with minor long-term effects to wetlands around the reservoirs<br>Green Peter – deep fall season drawdown with long-term moderate effects to wetlands around reservoir and negligible short-term effects (sediment) to downstream South Santiam reaches |

| Subbasin | Alternative 2A |
|---|---|
| | Green Peter and Detroit - localized erosion with short-term minor, adverse effects to wetlands |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with long-term benefits to streamside wetlands<br>South Fork McKenzie and Blue rivers – minor decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Cougar and Blue River - drawdowns with minor, long-term effects to wetlands around the reservoirs<br>Cougar and Blue River - localized erosion with short-term minor, adverse effects to wetlands |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with long-term benefits to streamside wetlands<br>Middle Fork Willamette – minor, decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor, long-term effects to wetlands around the reservoirs<br>Lookout Point, Hills Creek, and Fall Creek - localized erosion with short-term minor, adverse effects to wetlands |
| Coast Fork of the Willamette Subbasin | Negligible change |
| Mainstem Willamette River | Negligible change |

#### *3.7.2.6 Alternative 2B -- Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Similar to Alternative 2A, Alternative 2B stream flows will be adapted to fish survival and passage needs which is not anticipated to have a measurable effect to the frequency of inundation and therefore, would have negligible effects to PEM/PSS/PFO wetlands within the North Santiam, South Santiam, McKenzie, Coast Fork Willamette, and Middle Fork Willamette subbasins. In terms of effects to wetlands around reservoirs, Alternative 2B (similar to Alternative 1 and 2A) includes augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718), which both result in reservoir drawdowns below the normal rule curve elevations. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Cougar, Green Peter, and Detroit (as in Alternatives 1 and 2A) and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Fall Creek and Blue River and this measure allows the projects to drawdown the pools during the fall. As these drawdowns occur, the water table that provides hydrology to the wetlands around the reservoirs would drop. As the water table drops, wetlands would change in character (e.g, loss of wetland plants and soil moisture) and be less likely to provide ecological functions (e.g., water quality, wildlife habitat, biodiversity) over time. There is also the potential for minor adverse local effects to wetlands from localized erosion along the upstream reservoir rims due to either of these measures. If localized erosion did occur, there is potential that the debris could bury existing wetlands, ultimately causing a long-term loss of wetland function and acreage, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Because wetland surveys specific to these areas have not been conducted to date, it is impossible to quantify the wetland acreage that could be affected.

The primary difference between Alternatives 2A and 2B is that at the Cougar dam, the diversion tunnel will be used for fish passage for Alternative 2B whereas for Alternative 2A, an FSS will be used. Therefore, the primary difference between Alternative 2B and Alternative 2A is effects to wetlands as a result of spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40) in order to get the right water surface elevation for the diversion tunnel at Cougar reservoir, in addition to the deeper fall reservoir drawdown at Green Peter. . The spring reservoir drawdown at Cougar would occur May 1 to July 1 and the deeper fall reservoir drawdown at Cougar and Green Peter would occur October 15 to December 15. As the reservoir drawdowns occur, the water tables would lower within the wetlands that occur around the reservoir edges. These wetlands would become reliant on precipitation as the primary source of hydrology. During the spring and fall, precipitation is capable of supplementing the water that these wetlands need; however, it is not clear to what extent. The spring and fall drawdowns at Cougar and the fall drawdown at Green Peter are anticipated to cause moderate observable effects (e.g., dead or dying wetland vegetation) to wetlands around the reservoirs.

In addition to changes to the water tables in wetlands around Cougar and Green Peter reservoirs as a result of the spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40), there could be effects to wetlands as a result of localized erosion. Cougar reservoir has a mapped ancient landslide along the reservoir rim about 1.3 miles upstream of the dam and Green Peter has a large ancient landslide directly upstream of the dam, although it is difficult to tell from available information whether the landslide is in contact with the reservoir and drawdowns would therefore pose a risk of localized erosion. If localized erosion did occur, there is potential that the landslide debris could bury existing wetlands, ultimately causing a long-term loss of wetland function and acreage, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Because wetland surveys specific to these areas have not been conducted to date, it is impossible to quantify the wetland acreage that could be affected.

During the first couple years of the spring reservoir drawdowns (#720) and deeper fall reservoir drawdowns (#40) at Cougar and Green Peter, sediment releases are anticipated that could accumulate along downstream stream margins within the South Santiam and McKenzie subbasins, affecting the hydrologic connectivity between the active channels and streamside PEM/PSS/PFO wetlands. The sediment transported downstream could be deposited so that a wetland is further removed from the stream channel and is therefore less likely to be influenced by the flow within the active channel. Another possibility is that sediment could be deposited along the downstream channel in such a way that causes erosion of a nearby wetland as the streamflow adjusts around the deposited material. It should be noted that this sediment is anticipated to be flushed downstream after a couple of years of high flow events that typically occur in the winter and therefore, only a negligible short-term effect is anticipated.

##### *3.7.2.6.1 Near-term Operations Measure*

See Alternative 2A, Section 3.7.2.5.1, for description of effects due to the Near-Term Operations Measure.

##### *3.7.2.6.2 Climate Change*

See No Action Alternative, Section 3.7.2.2., for a description of effects due to Climate Change that applies to each action alternative for wetlands. In the case of Alternative 2B, the spring drawdown at Cougar and fall drawdown at both Cougar and Green Peter is anticipated to cause minor observable effects to wetlands around the reservoirs, but this would be compounded by climate change effects which are anticipated to cause long-term, moderate, and observable (at the regional scale) effects to wetlands throughout the WVS. Therefore, it is possible that the effects of the deep drawdowns combined with the effects of climate change could cause major effects to wetlands at Cougar and Green Peter reservoirs, including loss of wetland acreage and ecological functions specific to wetlands. It is worth noting that because on-the-ground wetland surveys have not been conducted, it is unclear how many wetlands and how large an area would be affected.

##### *3.7.2.6.3 Alternative 2B Wetlands Effects Summary Table*

Table 3.7-5 below presents a summary of the effects to wetlands within the WVS as a result of implementation of Alternative 2B.

**Table 3.7-5. Summary of Effects for Wetlands under Alternative 2B as Compared to the Alternative 2B -- Integrated Water Management Flexibility and ESA-Listed Fish Alternative**

| Subbasin | Alternative 2B |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with long-term benefits to streamside wetlands<br>North and South Santiam rivers - minor decreases to downstream flows with negligible long-term effects to streamside wetlands |

| Subbasin | Alternative 2B |
|---|---|
| | Green Peter and Detroit - drawdowns with minor long-term effects to wetlands around the reservoirs<br>Green Peter – deep fall season drawdown with long-term moderate effects to wetlands around reservoir and negligible short-term effects (sediment) to downstream South Santiam reaches<br>Green Peter and Detroit - localized erosion with short-term minor adverse effects to wetlands |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with long-term benefits to streamside wetlands<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Cougar and Blue River - drawdowns with minor long-term effects to wetlands around the reservoirs<br>Cougar – deep spring and fall season drawdowns with long-term moderate effects to wetlands around reservoir and negligible short-term effects (sediment) to downstream McKenzie reaches<br>Cougar and Blue River - localized erosion with short-termminor adverse effects to wetlands |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with long-term benefits to streamside wetlands<br>Middle Fork Willamette - minor decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor long-term effects to wetlands around the reservoirs<br>Lookout Point, Hills Creek, and Fall Creek - localized erosion with minor adverse localized effects to wetlands |
| Coast Fork of the Willamette Subbasin | Negligible change |
| Mainstem Willamette River | Negligible change |

#### *3.7.2.7 Alternative 3A – Improve Fish Passage Through Operations-Focused Measures*

Measures that would potentially affect the wetlands within the WVS as part of Alternative 3A include integrated temperature and habitat flow regime (#30a), which is not anticipated to have a measurable effect to the frequency of inundation and therefore would have negligible effects to PEM/PSS/PFO wetlands within the North Santiam, South Santiam, McKenzie, Coast Fork Willamette, and Middle Fork Willamette subbasins.

In terms of effects to wetlands around reservoirs, Alternative 3A (similar to Alternatives 1, 2A, and 2B) includes augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718), and augmenting instream flows by using the inactive pool (#718), which both result in reservoir drawdowns below the normal rule curve elevations. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Cougar, Green Peter, and Detroit (as in Alternatives 1, 2A, and 2B) and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Cottage Grove, Dorena, Fall Creek, and Blue River and this measure allows the projects to drawdown the pools during the fall. As these drawdowns occur, the water table that provides hydrology to the wetlands around the reservoirs would drop. As the water table drops, wetlands would change in character (e.g, loss of wetland plants and soil moisture) and be less likely to provide ecological functions (e.g., water quality, wildlife habitat, biodiversity) over time. There is also the potential for minor, adverse, local effects to wetlands from localized erosion along the upstream reservoir rims due to either of these measures. If localized erosion did occur, there is potential that the debris could bury existing wetlands, ultimately causing a long-term loss of wetland function and acreage, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Because wetland surveys specific to these areas have not been conducted to date, it is impossible to quantify the wetland acreage that could be affected.

In addition, a spring reservoir drawdown (#720) at Cougar, Detroit, and Lookout Point reservoirs (May 1 to July 1) and deeper fall reservoir drawdowns (#40) at Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point reservoirs (October 15 to December 15) for fish passage are part of Alternative 3A. These spring and fall drawdowns would also affect hydrologic conditions that support PEM/PSS/PFO wetlands that are along the reservoirs. As the reservoir drawdowns occur, the water tables would lower, making the wetlands reliant on precipitation as the primary source of hydrology. During the spring and fall, precipitation is capable of supplementing the water that these wetlands need; however, it is not clear to what extent. The spring and fall drawdowns are anticipated to cause moderate observable effects (e.g., dead or dying wetland vegetation) to wetlands around the reservoirs.

In addition to changes to the water tables in wetlands around Cougar and Green Peter reservoirs as a result of a spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40), there could be effects to wetlands as a result of localized erosion. Cougar reservoir has a mapped ancient landslide along the reservoir rim about 1.3 miles upstream of the dam and Green Peter has a large ancient landslide directly upstream of the dam, although it is difficult to tell from available information whether the landslide is in contact with the reservoir and drawdowns would therefore pose a risk of localized erosion. If localized erosion did occur, there is potential that the landslide debris could bury existing wetlands, ultimately causing a long-term loss of wetland function and acreage, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Because wetland surveys specific to these areas have not been conducted to date, it is impossible to quantify the wetland acreage that could be affected.

During the first couple years of the spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40), sediment releases are anticipated that could accumulate along downstream stream margins within the Middle Fork Willamette, North Santiam, South Santiam, and McKenzie subbasins, affecting the hydrologic connectivity between the active channels and streamside PEM/PSS/PFO wetlands. The sediment transported downstream could be deposited so that a wetland is further removed from the stream channel and is therefore less likely to be influenced by the flow within the active channel. Another possibility is that sediment could be deposited along the downstream channel in such a way that causes erosion of a nearby wetland as the streamflow adjusts around the deposited material. It should be noted that this sediment is anticipated to be flushed downstream after a couple of years of high flow events that typically occur in the winter and therefore, only a negligible short-term effect is anticipated.

##### *3.7.2.7.1 Near-term Operations Measure*

See Alternative 2A, Section 3.7.2.5.1, for description of effects due to the Near-Term Operations Measure.

##### *3.7.2.7.2 Climate Change*

See No Action Alternative, Section 3.7.2.2., for a description of effects due to Climate Change that applies to each action alternative for wetlands. In the case of Alternative 3A, spring drawdowns at Cougar, Detroit, and Lookout Point and deep fall drawdowns at Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point reservoirs are anticipated to cause minor observable effects to wetlands around the reservoirs, but this would be compounded by climate change effects which are anticipated to cause long-term, moderate, and observable (at the regional scale) effects to wetlands throughout the WVS. Therefore, it is possible that the effects of the deep drawdowns combined with the effects of climate change could cause major effects to wetlands at these reservoirs, including loss of wetland acreage and ecological functions specific to wetlands. It is worth noting that because on-the-ground wetland surveys have not been conducted, it is unclear how many wetlands and how large an area would be affected but because the deep drawdowns would be extensive for Alternatives 3A and 3B, major effects would be anticipated.

##### *3.7.2.7.3 Alternative 3A Wetlands Effects Summary Table*

Table 3.7-6 below presents a summary of the effects to wetlands within the WVS as a result of implementation of Alternative 3A.

**Table 3.7-6. Summary of Effects for Wetlands under Alternative 3A as compared to the Alternative 3A – Improve Fish Passage Through Operations-Focused Measures**

| Subbasin | Alternative 3A |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with long-term benefits to streamside wetlands<br>North and South Santiam rivers - minor decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Green Peter and Detroit - drawdowns with minor long-term effects to wetlands around the reservoirs<br>Detroit – fall and spring drawdowns with long-term moderate effects to wetlands around reservoir and negligible short-term effects (sediment) to downstream North Santiam and South Santiam reaches<br>Green Peter – deep fall season drawdown with long-term moderate effects to wetlands around reservoir and minor short-term effects (sediment) to downstream Middle Fork Willamette reaches<br>Green Peter and Detroit - localized erosion with short-term minor adverse effects to wetlands |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with long-term benefits to streamside wetlands<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Cougar and Blue River - drawdowns with minor effects to wetlands around the reservoirs<br>Cougar – deep spring and fall season drawdowns with long-term moderate effects to wetlands around reservoir and minor short-term effects (sediment) to downstream McKenzie reaches<br>Blue River – deep fall season drawdown with long-term moderate effects to wetlands around reservoir and minor short-term effects (sediment) to downstream McKenzie reaches<br>Cougar and Blue River - localized erosion with short-term minor adverse effects to wetlands |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with long-term benefits to streamside wetlands<br>Middle Fork Willamette - minor decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor long-term effects to wetlands around the reservoirs |

| Subbasin | Alternative 3A |
|---|---|
| | Lookout Point – deep spring and fall season drawdowns with long-term moderate effects to wetlands around reservoir and minor short-term effects (sediment) to downstream Middle Fork Willamette reaches<br>Hills Creek – deep fall season drawdown with long-term moderate effects to wetlands around reservoir and minor short-term effects (sediment) to downstream Middle Fork Willamette reaches<br>Lookout Point, Hills Creek, and Fall Creek - localized erosion with short-term minor adverse effects to wetlands |
| Coast Fork of the Willamette Subbasin | Negligible change |
| Mainstem Willamette River | Negligible change |

#### *3.7.2.8 Alternative 3B – Improve Fish Passage Through Operations-Focused Measures using Diversion Tunnel at COU*

In terms of measures that affect wetlands, Alternative 3B is very similar to Alternative 3A. One of the differences is that under Alternative 3B the spring reservoir drawdown (#720) would occur at Cougar, Green Peter, and Hills Creek reservoirs instead of Cougar, Detroit, and Lookout Point reservoirs. In addition, at Cougar the spring and fall drawdowns will be down to the diversion tunnel to allow for downstream fish passage. Another difference is that augmenting instream flows by using the power pool (#304) will not be implemented at Cougar for Alternative 3B as it had in Alternative 3A. Overall effects for Alterative 3B are characterized in more detail below.

A measure that could potentially affect the wetlands within the WVS as part of Alternative 3B include integrated temperature and habitat flow regime (#30a, which is not anticipated to have a measurable effect to the frequency of inundation and therefore would have negligible effects to PEM/PSS/PFO wetlands within the North Santiam, South Santiam, McKenzie, Coast Fork Willamette, and Middle Fork Willamette subbasins.

The spring reservoir drawdown (#720) at Cougar, Green Peter, and Hills Creek reservoirs (May 1 to July 1) and deeper fall reservoir drawdowns (#40) at Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point reservoirs (October 15 to December 15) for fish passage would affect hydrologic conditions that support PEM/PSS/PFO wetlands along the reservoirs. As the reservoir drawdowns occur, the water tables would lower, making the wetlands reliant on precipitation as the primary source of hydrology. During the spring and fall, precipitation is capable of supplementing the water that these wetlands need; however, it is not clear to what extent. Nor is it clear as to how seasons might shift within the next 30 years as a result of climate change. These effects, which would likely include a loss of wetland acreage, would be moderate. The spring and fall drawdowns are anticipated to cause moderate observable effects (e.g., dead or dying wetland vegetation) to wetlands around the reservoirs, while the long-term effects of climate change are anticipated to cause moderate, observable at the regional scale, effects to wetlands throughout the WVS.

In addition to changes to the water tables in wetlands around Cougar and Green Peter reservoirs as a result of the spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40), there could be effects to wetlands as a result of localized erosion. Cougar reservoir has a mapped ancient landslide along the reservoir rim about 1.3 miles upstream of the dam and Green Peter has a large ancient landslide directly upstream of the dam, although it is difficult to tell from available information whether the landslide is in contact with the reservoir and drawdowns would therefore pose a risk of localized erosion. If localized erosion did occur, there is potential that the landslide debris could bury existing wetlands, ultimately causing a long-term loss of wetland function and acreage, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Because wetland surveys specific to these areas have not been conducted to date, it is impossible to quantify the wetland acreage that could be affected.

During the first couple years of the spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40), sediment releases are anticipated that could accumulate along downstream stream margins within the Middle Fork Willamette, North Santiam, South Santiam, and McKenzie subbasins, affecting the hydrologic connectivity between the active channels and streamside PEM/PSS/PFO wetlands. The sediment transported downstream could be deposited so that a wetland is further removed from the stream channel and is therefore less likely to be influenced by the flow within the active channel. Another possibility is that sediment could be deposited along the downstream channel in such a way that causes erosion of a nearby wetland as the streamflow adjusts around the deposited material. It should be noted that this sediment is anticipated to be flushed downstream after a couple of years of high flow events that typically occur in the winter and therefore, only a negligible short-term effect is anticipated.

Alternative 3B includes augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718), which both result in reservoir drawdowns below the normal rule curve elevations. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Green Peter, and Detroit and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Cottage Grove, Dorena, Fall Creek, and Blue River and this measure allows the projects to drawdown the pools during the fall. There is also the potential for minor, adverse, local effects to wetlands from localized erosion along the upstream reservoir rims due to either of these measures. If localized erosion did occur, there is potential that the landslide debris could bury existing wetlands, ultimately causing a long-term loss of wetland function and acreage, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Because wetland surveys specific to these areas have not been conducted to date, it is impossible to quantify the wetland acreage that could be affected.

*3.7.2.8.1 Near-term Operations Measure*

See Alternative 2A, Section 3.7.2.5.1, for description of effects due to the Near-Term Operations Measure.

*3.7.2.8.2 Climate Change*

See No Action Alternative, Section 3.7.2.2., for a description of effects due to Climate Change that applies to each action alternative for wetlands. In the case of Alternative 3B, spring drawdowns at Cougar, Green Peter, and Hills Creek reservoirs and deep fall drawdowns at Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point reservoirs are anticipated to cause minor observable effects to wetlands around the reservoirs, but this would be compounded by climate change effects which are anticipated to cause long-term, moderate, and observable (at the regional scale) effects to wetlands throughout the WVS. Therefore, it is possible that the effects of the deep drawdowns combined with the effects of climate change could cause major effects to wetlands at these reservoirs, including loss of wetland acreage and ecological functions specific to wetlands. It is worth noting that because on-the-ground wetland surveys have not been conducted, it is unclear how many wetlands and how large an area would be affected but because the deep drawdowns would be extensive for Alternatives 3A and 3B, major effects would be anticipated.

*3.7.2.8.3 Alternative 3B Wetlands Effects Summary Table*

Table 3.7-7 below presents a summary of the effects to wetlands within the WVS as a result of implementation of Alternative 3B.

**Table 3.7-7. Summary of Effects for Wetlands under Alternative 3B as Compared to the Alternative 3B – Improve Fish Passage Through Operations-Focused Measures using Diversion Tunnel at COU**

| Subbasin | Alternative 3B |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with long-term benefits to streamside wetlands<br>North and South Santiam rivers - minor decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Green Peter and Detroit - drawdowns with minor long-term effects to wetlands around the reservoirs<br>Green Peter – deep fall and spring season drawdown with long-term moderate effects to wetlands around reservoir and minor |

| Subbasin | Alternative 3B |
|---|---|
| | short-term effects (sediment) to downstream South Santiam reaches<br>Detroit – deep fall season drawdown with long-term moderate effects to wetlands around reservoir and negligible short-term effects (sediment) to downstream North Santiam reaches<br>Green Peter and Detroit - localized erosion with short-term minor adverse effects to wetlands |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with long-term benefits to streamside wetlands<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Blue River - drawdown with minor long-term effects to wetlands around the reservoirs<br>Cougar – deep spring and fall season drawdowns (down to the diversion tunnel) with long-term moderate effects to wetland around reservoir and minor short-term effects (sediment) to downstream McKenzie reaches<br>Blue River – deep fall season drawdown with long-term moderate effects to wetlands around reservoir and negligible short-term effects (sediment) to downstream McKenzie reaches<br>Cougar and Blue River - localized erosion with short-term minor adverse effects to wetlands |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with long-term benefits to streamside wetlands<br>Middle Fork Willamette - minor decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor long-term effects to wetlands around the reservoirs<br>Hills Creek – deep spring and fall season drawdowns with long-term moderate effects to wetlands around reservoir and negligible short-term effects (sediment) to downstream Middle Fork Willamette reaches<br>Lookout Point – deep fall season drawdown with long-term moderate effects to wetlands around reservoir and negligible short-term effects (sediment) to downstream Middle Fork Willamette reaches<br>Lookout Point, Hills Creek, and Fall Creek - localized erosion with short-term minor adverse effects to wetlands |

| Subbasin | Alternative 3B |
| --- | --- |
| Coast Fork of the Willamette Subbasin | Cottage Grove and Dorena – drawdowns with minor long-term effects to wetlands around the reservoirs<br>Cottage Grove and Dorena - localized erosion with short-term minor adverse effects to wetlands |
| Mainstem Willamette River | Negligible change |

### *3.7.2.9 Alternative 4 – Improve Fish Passage with Structures-Based Approach*

Effects to wetlands from Alternative 4 would be similar to those of Alternative 1 since these both of these alternatives avoid spring and fall drawdowns and instead utilize structures for water quality and fish passage objectives. This alternative would include constructing water temperature control towers (#105) at Detroit, Hills Creek, and Lookout Point; Providing Pacific lamprey passage and infrastructure (#52) at Cougar, Dexter, and Hills Creek; restore upstream and downstream passage at drop structures (#639) on the Long Tom River downstream of Fern Ridge; and constructing structural downstream fish passage (#392) at Cougar, Detroit, Foster, Hills Creek, and Lookout Point. Measures included are focused on improving water quality and fish passage.

Measures that would potentially affect the wetlands within the WVS as part of Alternative 4 include integrated temperature and habitat flow regime (#30a), which is not anticipated to have a measurable effect to the frequency of inundation and therefore would have negligible effects to PEM/PSS/PFO wetlands within the North Santiam, South Santiam, McKenzie, Coast Fork Willamette, and Middle Fork Willamette subbasins.

In terms of effects to wetlands around reservoirs, Alternative 4 includes augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718), which both result in reservoir drawdowns below the normal rule curve elevations. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Cougar, Green Peter, and Detroit (as in Alternatives 1, 2A, 2B, and 3A) and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Cottage Grove, Dorena, Fall Creek, and Blue River and this measure allows the projects to drawdown the pools during the fall. As these drawdowns occur, the water table that provides hydrology to the wetlands around the reservoirs would drop. As the water table drops, wetlands would change in character (e.g, loss of wetland plants and soil moisture) and be less likely to provide ecological functions (e.g., water quality, wildlife habitat, biodiversity) over time. There is also the potential for minor, adverse, local effects to wetlands from localized erosion along the upstream reservoir rims due to either of these measures. If localized erosion did occur, there is potential that the landslide debris could bury existing wetlands, ultimately causing a long-term loss of wetland function and acreage, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Because wetland surveys specific to these areas have not been conducted to date, it is impossible to quantify the wetland acreage that could be affected.

#### *3.7.2.9.1 Near-term Operations Measure*

See Alternative 2A, Section 3.7.2.5.1, for description of effects due to the Near-Term Operations Measure.

#### *3.7.2.9.2 Climate Change*

See No Action Alternative, Section 3.7.2.2., for a description of effects due to Climate Change that applies to each action alternative for wetlands. Alternative 4 entails minor hydrologic effects to wetlands around the reservoirs and negligible hydrologic effects to riverine wetlands within the North Santiam, South Santiam, McKenzie, Coast Fork Willamette, and Middle Fork Willamette subbasins. Climate change is anticipated to cause moderate long-term effects to wetlands within the WRB, which would not be anticipated to be further exacerbated by Alternative 4 measures.

#### *3.7.2.9.3 Alternative 4 Wetlands Effects Summary Table*

Table 3.7-8 below presents a summary of the effects to wetlands within the WVS as a result of implementation of Alternative 4.

**Table 3.7-8. Summary of Effects for Wetlands under Alternative 4 as Compared to the Alternative 4 – Improve Fish Passage with Structures-Based Approach**

| Subbasin | Alternative 4 |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with long-term benefits to streamside wetlands<br>North and South Santiam rivers - minor decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Green Peter and Detroit - drawdowns with minor long-term effects to wetlands around the reservoirs<br>Green Peter and Detroit - localized erosion with short-term minor adverse effects to wetlands |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with long-term benefits to streamside wetlands<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible long-term effects to streamside wetlands |

| Subbasin | Alternative 4 |
|---|---|
| | Cougar and Blue River - drawdowns with minor long-term effects to wetlands around the reservoirs<br>Cougar and Blue River - localized erosion with short-term minor adverse effects to wetlands |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with long-term benefits to streamside wetlands<br>Middle Fork Willamette - minor decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor long-term effects to wetlands around the reservoirs<br>Lookout Point, Hills Creek, and Fall Creek - localized erosion with short-term minor adverse effects to wetlands |
| Coast Fork of the Willamette Subbasin | Cottage Grove and Dorena – drawdowns with minor long-term effects to wetlands around the reservoirs<br>Cottage Grove and Dorena - localized erosion with short-term minor adverse localized effects to wetlands |
| Mainstem Willamette River | Negligible change |

#### *3.7.2.10 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 5 is nearly identical to Alternative 2B. However, similar to Alternative 2B, Alternative 5 stream flows will be adapted to fish survival and passage needs except that the integrated temperature and habitat flow regime (#30a) has been replaced by the refined integrated temperature and habitat flow regime (#30b). Neither of these measures would have a measurable effect to the frequency of inundation and therefore, would have negligible effects to wetlands within the downstream aquatic and riparian areas of North Santiam, South Santiam, McKenzie, Coast Fork Willamette, and Middle Fork Willamette subbasins.

In terms of effects to wetlands around reservoirs, Alternative 5 (similar to Alternatives 1, 2A, and 2B) includes augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718), which both result in reservoir drawdowns below the normal rule curve elevations. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Green Peter, and Detroit (as in Alternatives 1 and 2A) and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Fall Creek and Blue River and this measure allows the projects to drawdown the pools during the fall. As these drawdowns occur, the water table that provides hydrology to the wetlands around the reservoirs would drop. As the water table drops, wetlands would change in character (e.g, loss of wetland plants and soil moisture) and be less likely to provide ecological functions (e.g., water quality, wildlife habitat, biodiversity) over time.

There is also the potential for minor adverse local effects to wetlands from localized erosion along the upstream reservoir rims due to either of these measures. If slope failures did occur, there is potential that the landslide debris could bury existing wetlands, ultimately causing a long-term loss of wetland function and acreage, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Because wetland surveys specific to these areas have not been conducted to date, it is impossible to quantify the wetland acreage that could be affected.

As with Alternative 2B, the diversion tunnel will be used for fish passage at the Cougar dam for Alternative 5. Therefore, the spring reservoir drawdown (#720) at Cougar would occur May 1 to July 1 and the deeper fall reservoir drawdowns (#40) at Cougar and Green Peter would occur October 15 to December 15. As the reservoir drawdowns occur, the water tables would lower within the wetlands that occur around the reservoir edges. These wetlands would become reliant on precipitation as the primary source of hydrology. During the spring and fall, precipitation is capable of supplementing the water that these wetlands need; however, it is not clear to what extent. The spring and fall drawdowns at Cougar and the fall drawdown at Green Peter are anticipated to cause moderate observable effects (e.g. dead or dying wetland plants) to wetlands around the reservoirs.

In addition to changes to the water tables in wetlands around Cougar and Green Peter reservoirs as a result of the spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40), there could be effects to wetlands as a result of localized erosion. Cougar reservoir has a mapped ancient landslide along the reservoir rim about 1.3 miles upstream of the dam and Green Peter has a large ancient landslide directly upstream of the dam, although it is difficult to tell from available information whether the landslide is in contact with the reservoir and drawdowns would therefore pose a localized erosion risk. If localized erosion did occur, there is potential that the landslide debris could bury existing wetlands, ultimately causing a long-term loss of wetland function and acreage, which would be considered a minor effect since effects are anticipated to be relatively small and limited to a certain area. Because wetland surveys specific to these areas have not been conducted to date, it is impossible to quantify the wetland acreage that could be affected.

During the first couple years of the spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40) at Cougar and Green Peter, sediment releases are anticipated that could accumulate along downstream stream margins within the South Santiam and McKenzie subbasins, affecting the hydrologic connectivity between the active channels and streamside PEM/PSS/PFO wetlands. The sediment transported downstream could be deposited so that a wetland is further removed from the stream channel and is therefore less likely to be influenced by the flow within the active channel. Another possibility is that sediment could be deposited along the downstream channel in such a way that causes erosion of a nearby wetland as the streamflow adjusts around the deposited material. It should be noted that this sediment is anticipated to be flushed downstream after a couple of years of high flow events that typically occur in the winter and therefore, only a negligible short-term effect is anticipated.

#### *3.7.2.10.1 Near-term Operations Measure*

See Alternative 2A, Section 3.7.2.5.1, for description of effects due to the Near-Term Operations Measure.

#### *3.7.2.10.2 Climate Change*

See No Action Alternative, Section 3.7.2.2., for a description of effects due to Climate Change that applies to each action alternative for wetlands. In the case of Alternative 5, the spring drawdown at Cougar and fall drawdown at both Cougar and Green Peter is anticipated to cause minor observable effects to wetlands around the reservoirs, but this would be compounded by climate change effects which are anticipated to cause long-term, moderate, and observable (at the regional scale) effects to wetlands throughout the WVS. Therefore, it is possible that the effects of the deep drawdowns combined with the effects of climate change could cause major effects to wetlands at Cougar and Green Peter reservoirs, including loss of wetland acreage and ecological functions specific to wetlands. It is worth noting that because on-the-ground wetland surveys have not been conducted, it is unclear how many wetlands and how large an area would be affected.

#### *3.7.2.10.3 Alternative 5 Wetlands Effects Summary Table*

Table 3.7-9 below presents a summary of the effects to wetlands within the WVS as a result of implementation of Alternative 5.

**Table 3.7-9. Summary of Effects for Wetlands under Alternative 5 as Compared to the Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)**

| Subbasin | Alternative 5 |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with long-term benefits to streamside wetlands<br>North and South Santiam rivers - minor decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Green Peter and Detroit - drawdowns with minor long-term effects to wetlands around the reservoirs<br>Green Peter – deep fall season drawdown with long-term moderate effects to wetlands around reservoir and negligible short-term effects (sediment) to downstream South Santiam reaches<br>Green Peter and Detroit - localized erosion with short-term minor adverse effects to wetlands |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with long-term benefits to streamside wetlands<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible long-term effects to streamside wetlands<br>Blue River - drawdowns with minor long-term effects to wetlands around the reservoirs<br>Cougar – deep spring and fall season drawdowns with long-term moderate effects to wetlands around reservoir and negligible short-term effects (sediment) to downstream McKenzie reaches<br>Cougar and Blue River - localized erosion with short-term minor adverse effects to wetlands |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with long-term benefits to streamside wetlands<br>Middle Fork Willamette - **minor** decreases to downstream flows with negligible long-term effects to streamside wetlands |

| Subbasin | Alternative 5 |
|---|---|
| | Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor ong-term effects to wetlands around the reservoirs<br>Lookout Point, Hills Creek, and Fall Creek - localized erosion with short-term minor adverse effects to wetlands |
| Coast Fork of the Willamette Subbasin | Negligible change |
| Mainstem Willamette River | Negligible change |

## 3.8 FISH AND AQUATIC HABITAT

This section covers fish and aquatic habitat found in the Willamette River and its tributaries. Management and conservation of these aquatic resources is a high priority for the U.S. Army Corps of Engineers (USACE) and one of the authorizing purposes of the WVS.

### 3.8.1 Affected Environment

The Affected Environment describes the anadromous and non-anadromous fish, and aquatic habitat affected by the WVS.

#### *3.8.1.1 Anadromous and Migratory Fish*

Operation and maintenance of the WVS affects aquatic wildlife and ESA-listed species in the WBR. Federally threatened anadromous and migratory fish species include:

- UWR spring Chinook salmon (*Oncorhynchus tshawytscha*),
- UWR winter steelhead (*Oncorhynchus mykiss*), and
- Bull trout (*Salvelinus confluentus*).

Although not federally listed under the ESA, Pacific lamprey (*Entosphenus tridentatus*) is another sensitive and culturally important anadromous fish also affected by the WVS. Pacific Lamprey are found in the Willamette Falls adult fishway (Hess et al. 2020), the mainstem of the Willamette (Clemens & Schrek, 2021), and there is some evidence of a landlocked population in the Middle Fork Willamette (Larson et al., 2020). About 3% of Snake River returns stray to the Willamette River (Hess et al., 2022). The Willamette River and its tributaries constitute one management unit, but it is generally recognized that distinct populations exist within this unit (ODFW, 2019). USACE currently incorporates lamprey features into new and existing adult salmonid facilities to pass lamprey upstream of the traps. Aside from routes in operation at each dam (e.g., spillways, turbine penstocks, regulating outlets), there are currently no specific facilities in place for passage of juvenile stages of lamprey downstream of dams.

In 1999, NMFS listed the Upper Willamette River Chinook evolutionarily significant unit (ESU) (*O. tshawytscha*) (UWR Chinook salmon) as a threatened species under the ESA. This ESU includes all naturally spawned populations of spring-run Chinook salmon in the Clackamas River and in the Willamette River, and its tributaries upstream of the Willamette Falls near Oregon City, OR. The Willamette/Lower Columbia Technical Recovery Team (WLCTRT) identifies seven independent, historical populations within this ESU:

- Clackamas River
- Molalla River
- North Santiam River
- South Santiam River

- Calapooia River
- McKenzie River
- Middle Fork Willamette River

Anadromous species rear (grow) in freshwater and migrate to the ocean. Chinook salmon emerge from gravel "redds" (i.e., nests), rear in freshwater, then migrate to the ocean a few months to one year after emergence. For this reason, medium-size cobble are preferred spawning characteristics because it allows for adequate flow and aeration. Adult Chinook salmon spend one to five years at sea before returning to freshwater to spawn. Chinook salmon are semelparous, that is – like coho, sockeye, pink, and chum salmon – they perish after spawning.

Table 3.8-1 is adapted from Table 3-4 from the NMFS 2008 Willamette Project Biological Opinion. The top row indicates the month of the calendar year. The rows indicate the life history stage. Darker shades indicate peak activity for the life stage, lighter shades indicate less pronounced life history stage activity. White cells indicate little or no life stage activity within the Willamette River system.

**Table 3.8-1. Life history timing for UWR spring Chinook salmon**

| Month | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upstream Migration | | | | | | | | | | | | |
| SpawnCing in Tributaries | | | | | | | | | | | | |
| Intragravel Development | | | | | | | | | | | | |
| Juvenile Rearing | | | | | | | | | | | | |
| Juvenile Out-migration | | | | | | | | | | | | |

UWR spring Chinook salmon are one of the most genetically distinct groups of Chinook salmon (Figure 3.8-1) in the Columbia River basin. Historically, before the placement of a fish ladder at Willamette Falls, passage by returning adult salmonids over Willamette Falls was possible only during the winter and spring high-flow periods. The early run timing of UWR Chinook salmon relative to other lower Columbia River spring-run populations is viewed as an adaptation to flow conditions at Willamette Falls. Since the Willamette Valley was not glaciated during the last epoch, the reproductive isolation provided by Willamette Falls was probably uninterrupted for a considerable time and provided the potential for significant local adaptation relative to other Columbia River populations.

The largest spring Chinook populations in the ESU were found historically in the North Santiam and the Middle Fork Willamette subbasins. The Coast Fork, Long Tom, and Blue River historically produced very small numbers, if any, spring Chinook.

Prior to the start of WVS dam construction in sub-basins where spring Chinook salmon populations occurred, the count of wild spring Chinook salmon returning to Willamette Falls was about 55,000 in 1946 and 47,000 in 1947. Although runs were already in decline due to fishing and land use practices, runs continued to diminish as WVS dams were constructed in the Santiam, McKenzie, and Middle Fork sub-basins. After 1960, less than 20,000 wild Chinook were counted at Willamette Falls. WVS dams and revetments were constructed mostly in eastside tributaries of the Willamette Basin during the 1950s and 1960s. WVS projects block access to critical habitat for Chinook and other ESA-listed species and more recently, the number of wild returns has been just over 10,000. While fish passage at high head dams continues to be evaluated, Congress approved authority for the Willamette Hatchery Mitigation Program (USACE, 1948).

**Figure 3.8-1. Adult Chinook Salmon – largest species of the Pacific salmonids**

Limiting factors identified in the UWR Recovery Plan (ODFW and NMFS 2011) for UWR Chinook and steelhead are listed below. All except the last two items, in part or in whole, can be related to effects of operation and maintenance of the WVS.

- Habitat access (impaired downstream passage of juveniles and steelhead kelts at water control facilities, leading to direct and delayed mortality) due to dams
- Habitat access (impaired adult access to holding and spawning habitat due to migration barriers) due to dams
- Habitat access (lack of spawning opportunity due to pre-spawning mortality impacts associated with handling stresses at sorting facilities and altered hydrology/WQ below dams)
- Population traits (impaired productivity and diversity) due to hatchery fish interbreeding with wild fish on the spawning grounds

- Competition (due to hatchery programs)
- Food web (impaired growth and survival from changes to estuarine food web)
- Predation by naturally produced native and non-native species, hatchery summer steelhead, hatchery rainbow trout, birds in the estuary
- Physical habitat quality due to excessive fine sediments due to land use practices
- Physical habitat quality due to flood control/hydropower sources
- Impaired habitat complexity and diversity
- Impaired water temperature
- Impaired water quality from input of toxins
- Altered hydrology below dams
- Insufficient stream flows and floodplain storage from land use practices
- Mortality from targeted fisheries and from bycatch

A recent summary of population viability was completed by NOAA NWFSC (NWFSC, 2022). Although NOAA has not completed a new status review since 2016, the information in the NWFSC report indicates the status of the UWR Chinook populations is likely unchanged from the previous status review completed (NOAA 2016). Figure 3.8-2 shows UWR Chinook spring salmon adult counts at Willamette Falls and population spawning abundance in key WRB sub-basins and Table 3.8-2 shows estimated risk of extinction for the various UWR populations.

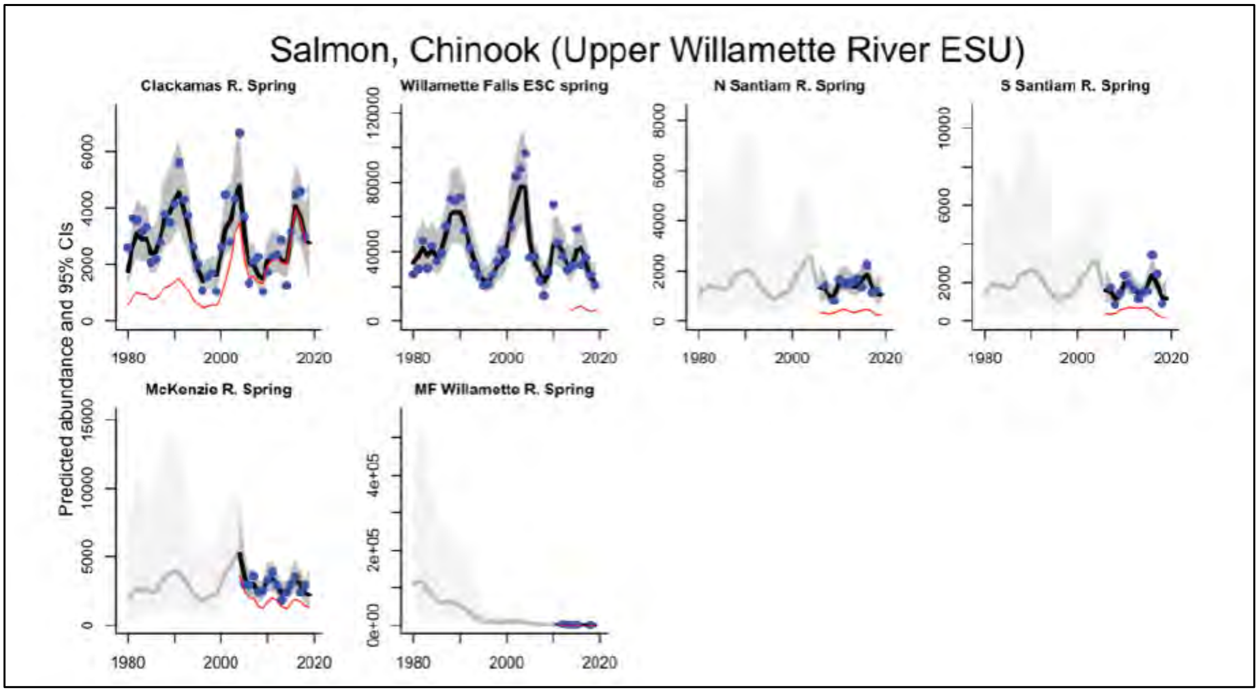



**Figure 3.8-2. Smoothed trend in estimated total (thick black line) and natural (thin red line) Willamette Falls counts and population spawning abundance. Points show the annual raw spawning abundance estimates. Chart from NWFSC (2022; Figure 79).**

**Table 3.8-2. Risk of extinction for UWR Chinook salmon (adapted from UWR Recovery Plan, ODFW & NMFS 2011, Table 3-3)**

| Stratum | Population | Extinction Risk Category |
|---|---|---|
| Upper Willamette | Clackamas | Low |
| | Molalla | Very High |
| | North Santiam | Very High |
| | South Santiam | Very High |
| | Calapooia | Very High |
| | McKenzie | Moderate |
| | Middle Fork Willamette | Very High |

The UWR steelhead (Figure 3.8-3) was listed as a threatened species under the ESA in 1999. This DPS includes all naturally spawned populations of winter-run steelhead in the Willamette River and its tributaries upstream of Willamette Falls to the Calapooia River. This distinct population segment (DPS) does not include any artificially propagated steelhead stocks that reside within the historical geographic range of the DPS. Hatchery summer-run steelhead occur in the Willamette River basin but are an out-of-basin stock that are not included as part of the DPS (71 FR 834). There are four independent populations recognized within the UWR winter-run steelhead DPS:

- Molalla River,
- North Santiam River,
- South Santiam River, and
- Calapooia River.

**Figure 3.8-3. Spawning Steelhead Trout**

Steelhead life history is slightly different than Chinook: juveniles rear in freshwater for one to three years, and can remain in the ocean up to six years. Furthermore, steelhead may be iteroparous, that is, they may return to the ocean after spawning. Spawners returning to the ocean are known as “kelts.” This fish species also express a completely freshwater life history type. Steelhead that remain in freshwater are said to “residualize” as rainbow trout. This flexibility allows the species to optimize resources in both the freshwater and ocean environments.

All runs of Chinook and steelhead are designated by the time of year which they return to freshwater as adults. In the Willamette, adult Chinook salmon enter the freshwater environment mainly in spring. These are known as spring Chinook salmon. Adult steelhead in the Willamette begin entering freshwater in the winter, with peak upstream migration rates in early spring, to take advantage of higher river flows which support upstream migration. These are referred to as winter steelhead.

Table 3.8-3 is adapted from Table 3-8 from the NMFS 2008 Willamette Project Biological Opinion. The top row indicates the month of the calendar year. The rows indicate the life history stage. Darker shades indicate peak activity for the life stage, lighter shades indicate less pronounced life history stage activity. White cells indicate little or no life stage activity within the Willamette River system.

Viability was determined by NMFS for all UWR steelhead populations at a moderate risk of extinction (Table 3.8-4) in their most recent status review (NMFS 2016). A recent summary of population viability was completed by NOAA NWFSC (NWFSC 2022). The information suggests the status of the populations likely remains the same as found in the most recent status review (NOAA 2016), however the NWFSC (2022) notes that the DPS has experienced a declining abundance trend.

**Table 3.8-3. Life history timing for UWR winter steelhead**

| Month | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upstream Migration | | | | | | | | | | | | |
| Spawning in Tributaries | | | | | | | | | | | | |
| Intragravel Development | | | | | | | | | | | | |
| Juvenile Rearing | | | | | | | | | | | | |
| Juvenile Out-migration | | | | | | | | | | | | |

**Table 3.8-4. Risk of Extinction Categories for UWR Steelhead Populations. Adapted from Table 3.4 in NOAA & ODFW 2011**

| Stratum | Population | Extinction Risk Category |
|---|---|---|
| Upper Willamette | Molalla | Moderate |
| | North Santiam | Moderate |
| | South Santiam | Moderate |
| | Calapooia | Moderate |

Data source: UWR Recovery Plan (ODFW and NMFS 2011).

Figure 3.8-4 shows the trend in population spawning abundance of the UWR steelhead from 1980 to 2019.

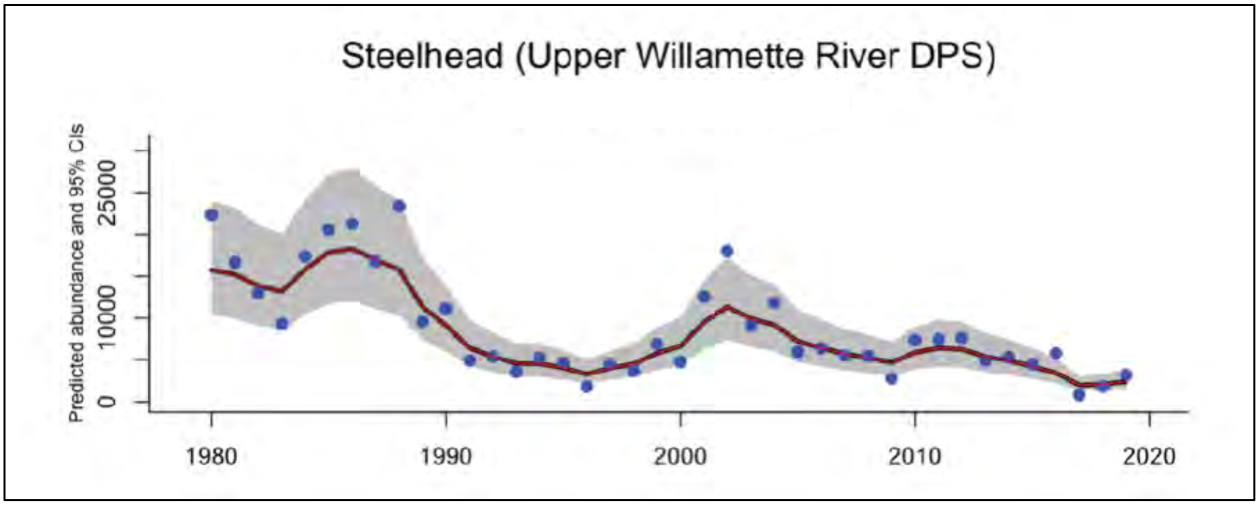



**Figure 3.8-4. Smoothed trend in estimated natural population spawning abundance.**

Note: Points show the annual raw spawning abundance estimates. Abundance estimates include both early (non-native) and late-winter (native) steelhead. Abundance estimates for Willamette Falls likely includes a much larger proportion of non-native fish than for the East Side tributary estimates. Points show the annual raw spawning abundance estimates. Chart from NWFSC (2022; Figure 87)

### *3.8.1.2 Non-Anadromous Fish*

The Willamette River Basin supports diverse populations of anadromous and resident fish species and aquatic organisms. These fish species are a mix of native and non-native (i.e., introduced) species. Table 3.8-5 lists the species found in the basin and their protected status.

**Table 3.8-5. Fish species found in the Willamette River Basin**

| Common name | Scientific name | Federal status | State status | Native or Introduced |
|---|---|---|---|---|
| Steelhead Trout | *Oncorhynchus mykiss* | Threatened | Sensitive-Critical | Native |
| Chinook Salmon | *Oncorhynchus tshawytscha* | Threatened | Sensitive-Critical | Native |
| Chiselmouth | *Acrocheilus alutaceus* | | | Native |
| Bull Trout | *Salvelinus confluentus* | Threatened | Sensitive | Native |
| Largescale Sucker | *Catostomus macrocheilus* | | | Native |
| Mountain Sucker | *Catostomus platyrhynchus* | | | Native |
| Prickly Sculpin | *Cottus asper* | | | Native |
| Mottled Sculpin | *Cottus bairdii* | | | Native |
| Paiute Sculpin | *Cottus beldingii* | | | Native |

| Common name | Scientific name | Federal status | State status | Native or Introduced |
|---|---|---|---|---|
| Shorthead Sculpin | *Cottus confuses* | | | Native |
| Riffle Sculpin | *Cottus gulosus* | | | Native |
| Reticulate Sculpin | *Cottus perplexus* | | | Native |
| Torrent Sculpin | *Cottus rhotheus* | | | Native |
| Pacific Lamprey | *Entosphenus tridentatus* | | Sensitive | Native |
| Threespine Stickleback | *Gasterosteus aculeatus* | | | Native |
| Western Brook Lamprey | *Lampetra richardsoni* | | Sensitive | Native |
| Peamouth | *Mylocheilus caurinus* | | | Native |
| Coastal Cutthroat Trout | *Oncorhynchus clarkii* | | | Native |
| Rainbow Trout | *Oncorhynchus mykiss* | | | Native |
| Oregon Chub | *Oregonichthys crameri* | | | Native |
| Sand Roller | *Percopsis transmontane* | | | Native |
| Mountain Whitefish | *Prosopium williamsoni* | | | Native |
| Northern Pikeminnow | *Ptychocheilus oregonensis* | | | Native |
| Longnose Dace | *Rhinichthys cataractae* | | | Native |
| Leopard Dace | *Rhinichthys falcatus* | | | Native |
| Speckled Dace | *Rhinichthys osculus* | | | Native |
| Redside Shiner | *Richardsonius balteatus* | | | Native |
| Brown Bullhead | *Ameiurus nebulosus* | | | Introduced |
| Western Mosquitofish | *Gambusia affinis* | | | Introduced |
| Pumpkinseed | *Lepomis gibbosus* | | | Introduced |

| Common name | Scientific name | Federal status | State status | Native or Introduced |
|---|---|---|---|---|
| Warmouth | *Lepomis gulosus* | | | Introduced |
| Bluegill | *Lepomis macrochirus* | | | Introduced |
| Smallmouth Bass | *Micropterus dolomieu* | | | Introduced |
| Largemouth Bass | *Micropterus salmoides* | | | Introduced |
| Coho Salmon | *Oncorhynchus kisutch* | | | Introduced |
| Kokanee | *Oncorhynchus nerka* | | | Introduced |
| White Crappie | *Pomoxis annularis* | | | Introduced |
| Black Crappie | *Pomoxis nigromaculatus* | | | Introduced |

Source: Snyder et al. 2006 and ODFW, personal communication

**Bull Trout**

Bull trout (Figure 3.8-5) are native to the Willamette River basin. The USFWS listed all populations of bull trout (*Salvelinus confluentus*) within the coterminous United States as a threatened species in 1999 (64 FR 58910). USFWS combines bull trout core habitat (i.e., habitat that could supply all elements for the long-term security of bull trout) with core populations (i.e., a group of one or more local bull trout populations that exist within core habitat) to create a "core area," which is the basic unit on which to gauge recovery within a unit. There are six bull trout recovery units which are used in the USFWS' Recovery Plan for the Coterminous United States Population of Bull Trout (2015). The Willamette River Basin – including the Upper Willamette River, Clackamas River, North Santiam River, and South Santiam River – is within the Coastal Recovery Unit (USFWS, 2015). Populations in the Willamette Basin currently exist in the Clackamas, McKenzie River and Middle Fork Willamette River basins. Bull trout populations also occupied portions of the North Santiam River historically, and were last observed there in 1945. USFWS is exploring the feasibility of expanding bull trout distribution into the North Santiam River (Hudson, 2017).

Of all the native salmonids in the Pacific Northwest of the United States, bull trout have the most specific habitat requirements, which are often referred to as "the four Cs": cold, clean, complex, and connected habitat. These requirements include cold water temperatures compared to other salmonids (often less than 54 degrees Fahrenheit); the cleanest stream substrates; complex stream habitat including deep pools, overhanging banks and large woody debris; and connectivity between spawning and rearing areas and downstream foraging, migration, and overwintering habitats. Bull trout populations are therefore dependent on cold-water fluvial habitat with limited human disturbance. In the Pacific Northwest, these habitats are largely located at high elevation, and suitable areas for spawning rearing, and foraging are patchily distributed. Habitat components that influence bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and migratory corridors (USFWS, 2015). In the Willamette Basin bull trout populations are located in the Cascade Mountains in areas that are the least impacted by human disturbances and maintain the coolest natural water temperatures in the basin. The WVS effects existing bull trout populations in the McKenzie and Middle Fork, which reside above Cougar Dam and Hills Creek Dam.

Connectivity to other habitat downstream of Cougar and Hills Creek dams could be important for several reasons, including: 1) population growth (especially for smaller populations) and life history diversity, 2) genetic exchange, 3) and, following catastrophic events, access to suitable habitat or recolonization sources. Climate adaptation is yet another reason habitat connectivity can be important. Major losses of suitable bull trout habitat throughout their range are expected from climate change projections (e.g., Isaak et al. 2012; Wenger et al. 2013). Reductions in downstream population boundaries for bull trout driven by climate change have already been observed (e.g. LeMoine et al., 2020).

Where risks are higher than the potential benefits, connectivity could be a detriment for bull trout. Downstream of Cougar and Hills Creek dams there is limited suitable spawning habitat for bull trout (Zymonas et al. 2021), and both human disturbances and water temperatures increase, thereby constraining the habitat value and risks for bull trout that move downstream. Individuals dispersing downstream therefore must “recruit” back to the spawning population above the dam. If the rate of spawner recruitment is lower than the rate of dispersal downstream, then downstream dispersal will result in population decline. If recruitment to the spawning population is not maintained by individuals remaining above the dam, then local extinction could occur (e.g. Al-Chokhachy et al., 2015). The likelihood of genetic exchange among populations above Cougar and Hills Creek dams appears low given the number of dams fish need to pass, effects of poor habitat conditions in lower watershed areas on bull trout survival rates and migration patterns, and lack of genetic exchanged documented (see Zymonas et al. 2021). In the face of climate change with the potential for increasing water temperatures, the negative consequences of connectivity become ever more important for managers to consider. Dispersal by bull trout downstream of WVS dams may be maladaptive for bull trout in today’s degraded environment below WVS dams, lack of spawning habitat, and expected further degradation with climate change.

Under existing conditions, bull trout populations above Cougar dam are stable (Figure 3.8.6) and the bull trout population above Hills Creek Dam has been steadily increasing in abundance for nearly a decade (Figure 3.8.7), based on redd counts reported by Zymonas et al. (2021). Depending on the type of action taken, changing fish passage conditions could increase emigration rates of bull trout downstream of these dams. It is uncertain if this will lead to net-negative effects for the currently stable/growing populations above WVS dams and result in a decline in recruitment and spawner abundance, or provide a net positive effect by expanding rearing and forage opportunities. Managing or minimizing changes in habitat conditions, especially below dams where human impacts are higher, will be difficult to achieve due to the pervasive nature of climate change and the limited extent of restoration actions (e.g. Isaak et al. 2022).

**Figure 3.8-5. Bull Trout (*Salvelinus confluentus*)**

Figure 3.8-6 shows the generally upward trend in **annual redd counts from 2005 to 2019 for bull trout in the Roaring River, a tributary of the South Fork McKenzie above Cougar Dam**.

Figure 3.8-7 shows a steeper upward trend since 2013 in annual redd counts for bull trout above Hills Creek Dam in the Middle Fork Willamette Basin.

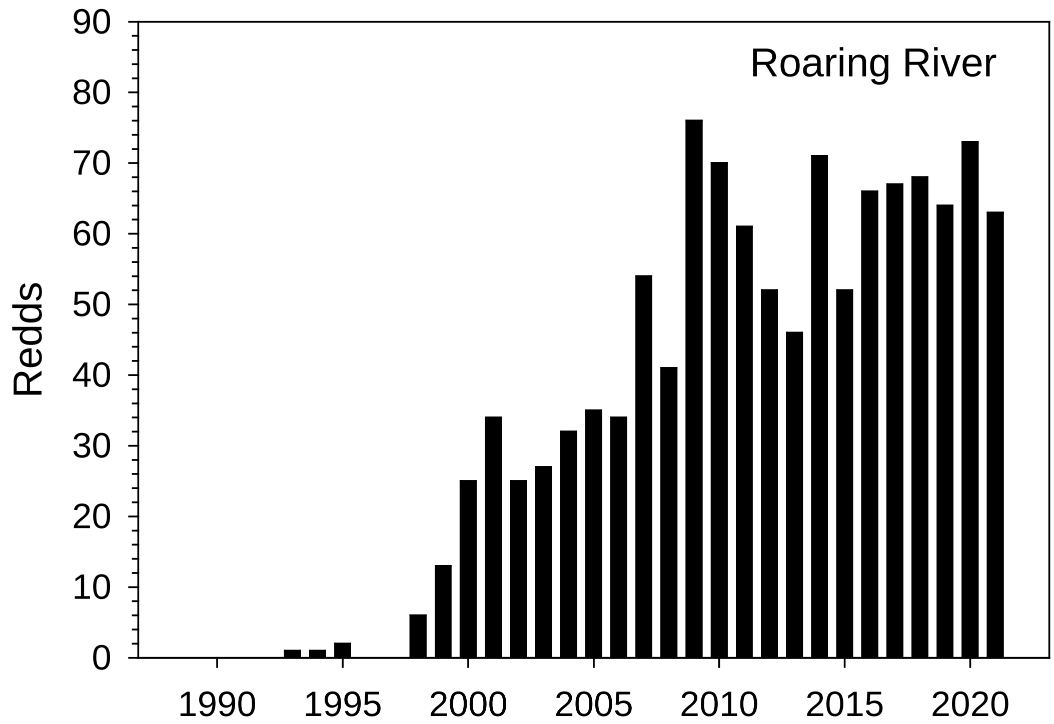



**Figure 3.8-6. Annual redd counts for bull trout in the Roaring River, a tributary of the South Fork McKenzie above Cougar Dam. Figure reproduced from Zymonas et al. 2022.**

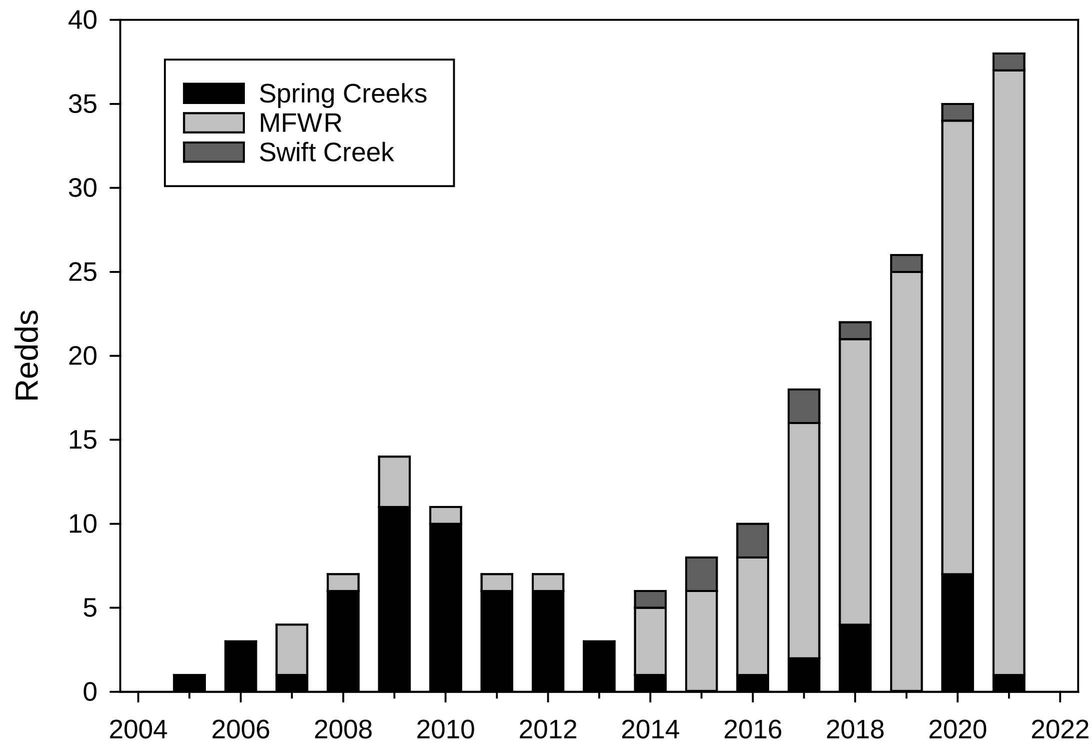



**Figure 3.8-7. Annual redd counts for bull trout in the Middle Fork Willamette Basin, above Hills Creek Dam. Figure reproduced from Zymonas et al. 2022.**

## Oregon Chub

Oregon chub (*Oregonichthys crameri*) is a native *cyprinid* that is found in the Willamette River basin primarily in off-channel or floodplain habitats with little to no water velocity. USFWS listed Oregon chub as endangered in 1993 and reclassified as threatened in 2010. When listed in 1993 there were only 1,000 known individuals. However, thanks to conservation efforts, the population grew to over 140,000 fish in at least 80 habitats by the time of delisting in 2015 (Figure 3.8-8). USFWS officially de-listed Oregon Chub on February 17, 2015 (USFWS, 2015).

ODFW has been implementing the Post-Delisting Monitoring Plan for the Oregon Chub (USFWS, 2014). The purpose is to track changes in distribution, abundance, habitat conditions, and threats after delisting. Relevant information for the North Santiam sub-basin is included below and is from the 2017 Oregon Chub Investigations Report (Bangs and Meeuwig, 2018).

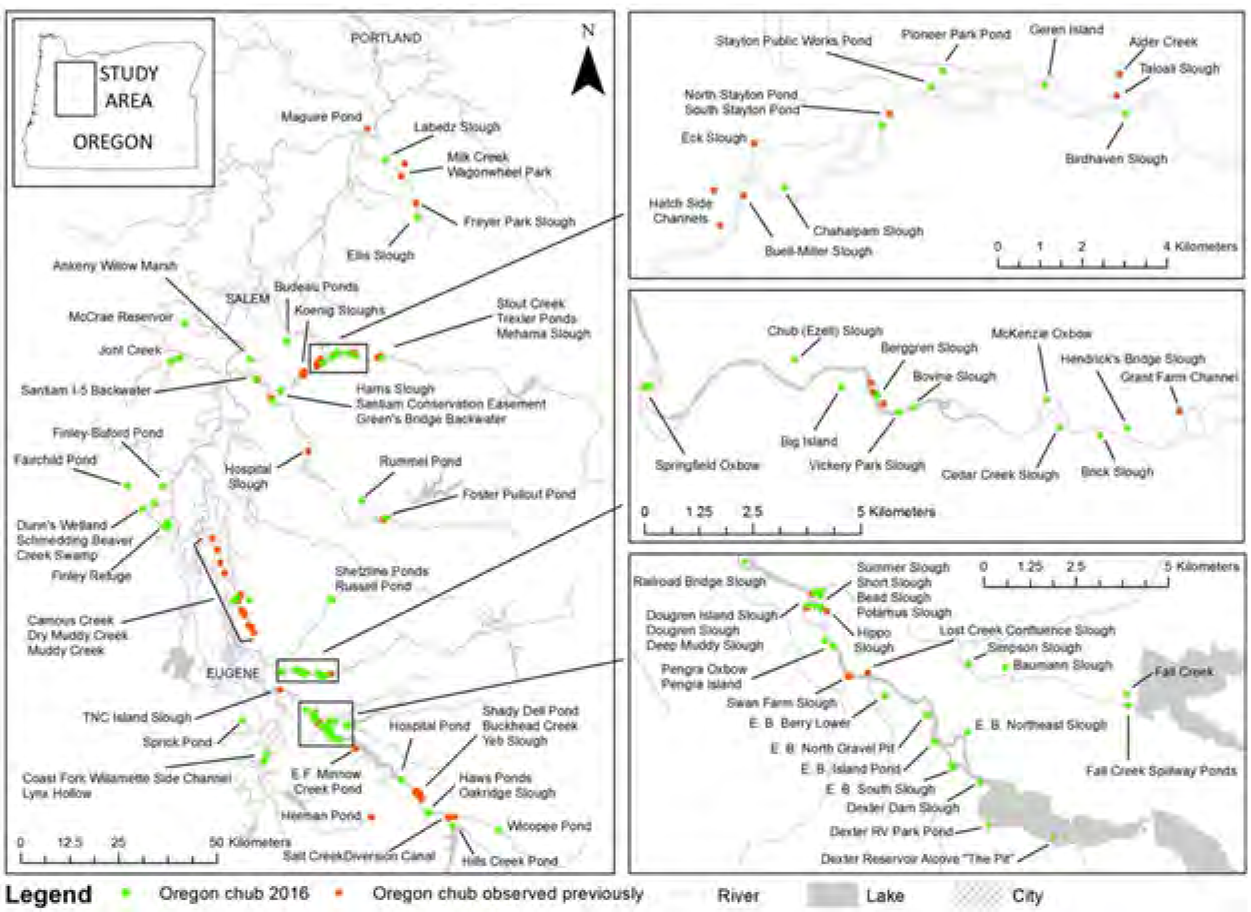



**Figure 3.8-8. All known Oregon Chub population in the Willamette River basin in 2017**

Note: Green circles indicate locations where Oregon Chub were detected during sampling. Red circles indicate locations where Oregon Chub were not detected during sampling but were observed previously. Overlapping symbols represent multiple locations occurring at or near the same survey location. Figure is from ODFW 2017 Oregon Chub Investigations (2018).

**Coastal Cutthroat Trout**

Coastal Cutthroat trout (*Oncorhynchus clarkii clarkii*) can be found in the Willamette River drainage into the headwaters of most tributaries (such as Stout, Ayers, and Shellburg Creeks) as well as a fluvial population (BLM, 2006). Anadromous coastal cutthroat trout have not be documented above Willamette Falls. The species management unit above Willamette Falls is considered 'not at risk' due to its wide distribution, relatively high abundance, and resilience to events that reduce abundance (ODFW, 2005).

**Rainbow Trout**

Native rainbow trout (*Oncorhynchus mykiss*) are river and lake dwelling in the Willamette River Basin, which provides habitat for all life stages. In addition to the native population, triploid (sterile) hatchery rainbow trout are released at various locations to provide for sport fishing opportunities. These hatchery fish come from various facilities (Leaburg, Willamette, Roaring River, Wizard Falls, Marion Forks, and Desert Springs). Although management operations proposed in this draft PEIS are not expected to impact native rainbow trout, there is evidence that stocked rainbow trout may affect native spring Chinook salmon and winter steelhead through competition and possibly predation (ref).

**Kokanee**

Kokanee (*Oncorhynchus nerka*) are a non-migratory sockeye salmon and are currently stocked to support a popular sport fishery. Kokanee are not native to the Willamette River Basin and were first stocked by the Oregon Fish Commission in 1959 (Wetherbee et al. 1965). Effects of non-native kokanee on native species have not been documented. Kokanee have become a major fishery for many anglers that contribute to the recreation attraction, local businesses, and livability of the area.

There are two types of kokanee salmon: stream spawners and lake shoreline spawners. During rearing and foraging, they inhabit the lake. Sexual maturity usually occurs at age three. For example, Kokanee in Detroit Reservoir naturally reproduce in the North Santiam River and tributaries, such as the Breitenbush, Tumble, French and Blowout Creeks, in the fall (Wetherbee, 1965).

Kokanee compete for zooplankton with other species in the lake whether stocked or naturally spawned. Monthly zooplankton data collected by Kokanee Power of Oregon (KPO) volunteers in recent years at Detroit Reservoir indicate there is sufficient zooplankton to support a healthy kokanee population. Low food supply reduces the kokanee growth rate. Large rainbow trout have been known to feed on kokanee.

Kokanee are most often found in deeper colder water and during the summer months are 80-100 feet below the surface in the reservoir but will change their depth depending on water temperature.

**Western Brook Lamprey**

The western brook lamprey is found in the Willamette River basin and is likely the second most common and widely distributed lamprey in Oregon after the Pacific lamprey (Kostow 2002 as cited in ODFW 2005). Western brook lampreys have no special state or federal status but are considered by the state as “at risk” (ODFW, 2005). Overall, little is known about western brook lamprey abundance and productivity in the Willamette River Basin.

### *3.8.1.3 Willamette System Features*

The lower Willamette consists mostly of sandy shores, rocky outcrops, and vegetated riprap that is seasonally available for use by aquatic fish and invertebrates (Friesen et al. 2005). Overall, water quality is good in upstream river sections closer to the foothills of the Cascades and declines with respect to temperature, oxygen demands, and agricultural nutrification downstream (Krass et al. 2021).

The Willamette River has undergone substantial man-made alterations and simplification since the 1850’s (Krass et al. 2021) including WVS project operations beginning in the early to mid-1900’s. The Willamette Falls Adult Fishway was constructed in the late 1880’s despite the fact that the falls presented a natural barrier to passage (Bennett 1986). Operation of the WVS may affect aquatic species by altering river flow and water temperatures, foremost in tributaries where WVS dams exist, and by impeded or blocking migration to and from habitat. Flood flows downstream of the WVS system have been reduced, and summer low flows have been increased. Water temperatures are generally cooler in summer below dams within tributaries. In fall, when water is discharged from reservoirs to support flood risk management, water temperatures below dams can be warmer than pre-dam conditions. These changes in river flow and water temperatures as discharged from WVS dams has altered the availability of aquatic habitat and biological responses of aquatic organisms (Figure 3.8-9).

In addition to dams, the WVS included construction of revetments to reduce bank erosion along the mainstem Willamette River and lower reaches of its major tributaries. The upper Willamette River upstream of Salem has been transformed from a braided to a channelized system along the valley floor to accommodate urbanization and agricultural expansion (Wallick et al. 2007). In reaches now seasonally or continuously impounded by dam operations, aquatic habitat has substantially changed, supporting animals and plants capable of using more lentic-type habitat conditions.

**Figure 3.8-9. Adult Mayfly**

Several actions have been completed over the last 10-15 years to restore access of Chinook and steelhead to habitat upstream of WVS dams, including construction of four new adult fish facilities (Minto, Foster, Cougar and Fall Creek) for collection and transport of adult Chinook and steelhead to spawning habitat upstream of WVS dams in the North Santiam River, South Santiam River, South Fork McKenzie and Fall Creek. Downstream fish passage actions have also been taken at Foster Dam with use of a fish spill weir, and an annual reservoir drawdown to riverbed elevation at Fall Creek Dam. Ongoing efforts include operations for downstream fish passage and temperature improvement implemented at several dams, improvements to road access to adult fish release sites at spawning grounds above the dams, and ongoing research to fill data gaps supporting alternative selection and design. While it is generally accepted that upstream passage can be accomplished through appropriate infrastructure and best management practices using traps and trucks, downstream passage effectiveness is less certain and potential solutions are complicated by large water level elevation fluctuations in reservoirs for flood control. Therefore, the WVS project effects are less certain with respect to the feasibility of juvenile downstream survival.

#### *3.8.1.4 Hatcheries, wild salmon, and steelhead*

When the WVS was authorized, the dams were anticipated to have a negative impact on wild salmon and steelhead runs. Hatchery production of Chinook salmon, steelhead, and game fish already established by the state of Oregon was increased to mitigate for lost habitat above WVS dams. These hatchery programs originally included winter steelhead, however at the request of the state of Oregon, the Corps-funded winter steelhead hatchery was discontinued in the 1980’s in favor of summer steelhead. Over time, the resident fish hatchery program was also simplified from a program of several species to solely rainbow trout production with a Corps funded annual basin-wide release of 277,000 pounds (ODFW and USACE, 2016). In recent years, the total abundance of wild spring Chinook upstream migration at Willamette Falls was just over 10,000 annually, while total abundance of hatchery spring Chinook upstream migration at Willamette Falls is around 20,000.

**Table 3.8-6. Hatchery production goals (number of smolts) for UWR spring Chinook salmon in each sub-basin according to the Hatchery Genetics Management Plans**

| Sub-basin | ESA Conservation Purpose (per HGMP) | Remaining Discretionary Corps Release (per HGMP) | ODFW-funded Release per HGMP | Total Hatchery Release |
|---|---|---|---|---|
| North Santiam | 630,000 | 74,000 | 0 | 704,000 |
| South Santiam | 350,000 | 289,000 | 382,000 | 1,021,000 |
| McKenzie | 604,750 | 0 | 0 | 604,750 |
| Middle Fork Willamette | NA | 2,039,000 | 0 | 2,039,000 |

**Table 3.8-7. Hatchery production goals (number of smolts) for summer steelhead in each sub-basin according to the Hatchery Genetics Management Plan**

| Sub-basin | Discretionary Corps Release (per HGMP) | ODFW-funded Release per HGMP | Total Hatchery Release |
|---|---|---|---|
| North Santiam | 0 | 121,000 | 121,000 |
| South Santiam | 0 | 121,000 | 121,000 |
| McKenzie | 0 | 108,000 | 108,000 |
| Middle Fork Willamette/Mainstem | 157,000 | 0 | 157,000 |

USACE's hatchery programs – UWR spring Chinook salmon, summer steelhead, and rainbow trout – can impact ESA-listed fish through fish attenuation to a captive rearing environment, a reduction in the frequency of wild type genes (i.e., domestication effects), increased risk of pre-spawn mortality, competition, introgression, predation, and recreational fishery impacts. Much research is available regarding these potential impacts (Christie et al. 2016, Araki et al. 2009, Araki et al. 2008, Weber and Fausch 2003, Wang et al. 2002, Fleming and Petersson 2001, Berejikian 1995, Waples 1991, Reisenbichler and McIntyre 1977). Genetic effects of hatchery fish have been observed over as few as one salmon generation, when offspring had one hatchery parent (Araki et al. 2008). Several studies in salmonids have shown that wild-born fish achieve greater fitness in the wild than hatchery fish (Araki et al. 2008, Anderson et al. 2013, Milot et al. 2013) including studies in the Willamette (O'Malley et al. 2014).

The proportion of hatchery origin spawners below dams is currently very high, and would not be expected to change in the future even when fish passage at dams is improved unless decisions are made to reduce hatchery releases. Offspring of hatchery spawners below dams are not marked when they return, and some will be inadvertently outplanted above dams. For example, in the South Santiam, where only unclipped (or non-adipose fin clipped) fish are to be outplanted above Foster Dam, otolith data reported by ODFW indicate that non-clipped hatchery origin fish represent about 12% of “NOR” salmon released above Foster Dam (ODFW 2014).

Due to low abundance of naturally produced spring Chinook, hatchery spring Chinook are being used to supplement the natural origin population to promote reintroduction efforts above WVS dams. The ODFW and NMFS Upper Willamette River Conservation and Recovery Plan (2011) describes an approach to isolate natural from hatchery origin spawners using a “split-basin” approach, whereby wild fish refuges are designated above dams. Below dams, hatchery fish would continue to spawn with wild fish, or would be collected at trapping facilities for brood, outplanting above dams to support reintroduction, or food. The effectiveness of a split-basin approach to adequately control effects of hatchery fish on wild Chinook and steelhead population has not been demonstrated. Wild fish production below dams is already impacted by degraded habitat conditions, and is expected to continue to have very high levels of hatchery origin spawners, among other factors. Releases of juvenile hatchery Chinook and steelhead below dams may result in competition when juvenile hatchery Chinook are released below dams and negative fitness effects when hatchery adults return and spawn in the wild.

Since both wild and hatchery fish must utilize below dam habitat during their juvenile and adult phases, effects may remain for both the below and above dam wild population components. Therefore, hatchery practices can be expected to constrain wild salmon and steelhead population performance once fish passage is provided through a variety of ways and to varying degees including competition, genetic introgression (breeding between hatchery and wild fish), increased pre-spawn mortality, and decreased fecundity. Some recent scientific studies indicate that the hatcheries themselves may have detrimental impacts to wild ESA-listed species without directed management and careful consideration of production levels given available habitat (Paquet et al. 2011). Stocking of rainbow trout may also lead to competition with rearing juvenile salmon and steelhead (NMFS 2008).

The Upper Willamette Hatchery Programs final EIS evaluated the Hatchery Genetic Management Plans to determine the risk of jeopardy to ESA-listed (NMFS 2019). NMFS determined that an integrated hatchery for Chinook salmon (i.e., a hatchery where a small proportion of natural origin fish are taken for the production of hatchery fish in the following year) in the Willamette posed some risks but did not result in jeopardy to either UWR spring Chinook or winter steelhead (NMFS 2019). Increasing the proportion of naturally-produced fish into the hatchery broodstock was also identified by the Hatchery Science Review Group (HSRG) in 2009 as an important way to improve the status of UWR Chinook salmon. Currently the spring Chinook hatchery programs integrate natural origin brood on the schedule and terms developed in the 2019 Hatchery BiOp (NMFS, 2019). Integration rates for 2019 to 2021 are provided in Table 3.8-8. Integration of natural origin brood into Chinook hatchery broodstock has occurred on a limited basis in recent years (pNOB range 0.0 to 0.15), and therefore the high levels of hatchery origin spawners both above and below the dams in the WVS are potentially reducing the fitness in naturally spawning populations. Natural origin brood summer steelhead are a strictly introduced species in the Willamette Basin, and so there is no ability to incorporate natural origin brood. Therefore, summer steelhead spawning in the wild with native winter steelhead will continue to result in negative genetic effects for UWR steelhead.

**Table 3.8-8. The proportion of natural origin brood used in spring Chinook spawning hatcheries in recent years (2019-2021). Data provided by K. Reis, personal communication to R. Piaskowski, April 2022.**

| Collection Facility | Return Year | Total Number of Natural-origin salmon (NOR) collected | Number of NOR used in Broodstock | Total Number of Broodstock Spawned | Proportion of Natural Origin Brood (pNOB)[1] |
|---|---|---|---|---|---|
| Minto | 2019 | 827 | 0 | 476 | 0.00 |
| | 2020 | 1,626 | 46 | 446 | 0.10 |
| | 2021 | 482 | 0 | 404 | 0.00 |
| Foster | 2019 | 133 | 0 | 314 | 0.00 |
| | 2020 | 354 | 0 | 283 | 0.00 |
| | 2021 | 173 | 0 | 352 | 0.00 |
| McKenzie[2] | 2019 | 138 | 100 | 654 | 0.15 |
| | 2020 | 34 | 34 | 471 | 0.07 |
| | 2021 | 15 | 5 | 555 | 0.01 |
| Dexter[3] | 2019 | 190 | 87 | 1,502 | 0.06 |
| | 2020 | 196 | 74 | 1,545 | 0.05 |
| | 2021 | 58 | 5 | 870 | 0.01 |

[1] pNOB is calculated as the number of unmarked (NOR) broodstock divided by the total number of broodstock. As limiting factors such as downstream passage and habitat (including flow and water quality) are addressed, the number of NORs should increase over time. With higher NORs, increased NOR integration rates may occur within the terms of the HGMPs, resulting in a higher future pNOB.

2 Total includes Chinook collected at McKenzie and Leaburg Hatchery traps. Total does not include fish handled at the Leaburg Sorter.

[3] Total includes broodstock collected for Middle Fork and Coast Fork Willamette basin releases. Offspring of NOR brood are only released into the Middle Fork Willamette basin.

Note: Information provided by K. Reis with ODFW by email to R. Piaskowski on April 27, 2022.

In addition to the potential for reducing fitness in naturally spawned populations, hatchery rearing practices can impact smolt success by increasing competition with wild fish. Hatchery fish tend to be naïve to predators which can increase wild fish vulnerability to predation when hatchery releases are high. These processes operate through density dependence, i.e., at high densities, there may be too many individuals for the habitat to support which may increase competition and predation vulnerability. Although the magnitude of density dependence is uncertain in the Willamette, there is some evidence of habitat saturation within the broader Columbia Plateau. Density-dependent effects due to high hatchery production levels and hatchery adult returns are described for the Columbia River (ISAB, 2015), and in integrated model exercises for the Willamette River Basin (Scheuerell, 2019). Density dependence among

UWR spring Chinook is possible with greater hatchery production (Particularly under currently implemented production schedules to meet the need for hatchery production in the next year), conservation, and harvest goals.

USACE's hatchery mitigation obligations may, at times, be in conflict with other agency missions. ODFW continues to operate a summer steelhead program exclusively for harvest within winter steelhead DPS habitat (e.g., North and South Santiam) while the Corps has discontinued its program in these sub-basins. Hatchery summer steelhead generally demonstrate lower overall ability to survive and reproduce than winter steelhead. Weigel et al. (2018) found evidence of summer-winter steelhead hybridization, and genetic information indicated consistently lower summer steelhead productivity when compared to winter steelhead. Competition between the two juvenile run types has been described for the Clackamas (Kostow et al., 2003) and may occur in the Willamette where the two forms overlap in space and time. Recent work has demonstrated a minimum residualization rate (i.e., the rate at which non-native summer steelhead remain in the North Santiam basin after release) of at least 12% (Harnish et al. 2014). Declines in winter steelhead productivity, increased competition with non-native summer steelhead, and potential summer steelhead predation on juvenile spring Chinook may have negative impacts for ESA listed species in the WBR.

Hatchery produced rainbow trout potentially pose some risks to spring Chinook and winter steelhead. Both State and Corps rainbow trout hatchery programs result in spatial overlap with ESA-listed juvenile winter steelhead and spring Chinook within standing water bodies (i.e., WVS project reservoirs). There are concerns with respect to competition with winter steelhead and predation on Chinook and steelhead fry (ODFW & USACE 2018). Promoting local fisheries with trout stocking also results in take of juvenile Chinook and steelhead.

Given the potential for significant effects that can occur, the maintenance of harvest hatchery programs has the potential to constrain the ability to re-establish sustainable wild fish populations of Chinook and steelhead above WVS dams, even with improved fish passage. The hatchery BiOp (2019) endorsed management actions to reduce summer steelhead production levels in the South Santiam and update acclimatization practices in the North Santiam to discourage spatial overlap between summer steelhead and winter steelhead. The effects of juvenile releases and adult returns of hatchery fish will need to be carefully monitored in order for a split-basin approach to ensure there is not a substantial impact wild fish populations.

#### *3.8.1.5 Hatchery risk metrics and performance*

Several metrics assist hatchery managers to determine the level of genetic hatchery influence on ESA-listed species. Johnson and Friesen (2014) demonstrated that UWR hatchery origin spring Chinook salmon are genetically similar to the wild type; however genetic introgression (i.e., when genes from hatchery fish show up in wild fish) and spawner densities are consistently monitored to assess population risks and performance. The proportion of hatchery origin spawners present on the spawning ground (pHOS), allows managers to assess potential introgression with wild origin spawners within the DPS and wild spawner contribution to reintroduction above projects. pHOS targets are set for each basin and generally range from 10 to 20% above project with exceptions where native fish populations have not yet been re-established (ODFW & USACE 2016a, ODFW & USACE 2016b, ODFW & USACE 2016c, ODFW & USACE 2016d). Results from baseline monitoring show that pHOS is higher below dams, often near 100% in some cases (Sharpe 2018). Above dams, pHOS can vary from 1 to 99% (Sharpe 2018) depending on the adult release strategy (outplanting) and level of passage at dams. pHOS above dams is expected to potentially decrease as passage is implemented if outplanting protocols are changed to be generally more consistent with the state recovery plan (ODFW 2011).

Managers measure population sustainability using Cohort Replacement Rate (CRR), or the ability of one generation to produce enough successful mature progeny to replace them. The CRR allows managers to gauge the productivity of each generation to determine if spawner cohorts are at least replacing themselves (value of 1), or declining (value less than 1). On average, values greater than 1 indicate a growing population and values less than 1 indicate population decrease or population capacity (i.e., maximum number of adults have been produced given the available habitat). Hatchery production levels in the HGMP's have been determined based on the number of smolts and expected survival that will result in a CRR value of at least 1. Replacement is observed below projects but pHOS and the potential for introgression remains high (Sharpe et al. 2018).

Rates of mortality of adults prior to spawning (pre-spawn mortality) are believed to likely increase with increased hatchery production (Bowerman et al. 2018, Benda et al. 2015, Keefer et al. 2017), which likely reflects negative effects of high densities of adults during migration, holding or spawning, particularly below dams. Pre-spawn mortality varies throughout the system and is associated with warmer stream temperatures (Benda et al. 2015), body condition (Keefer et al. 2017), travel time (Caudill et al. 2017), elevation, and pathogenicity (Bowerman et al. 2018). Spawners entering the dam tailrace or traps may be more vulnerable to pre-spawn mortality due to lengthened travel times, higher fish densities, and increased handling/holding associated with sorting fish for reintroduction versus other program purposes (e.g., fishing opportunity). These factors appear to have greater effects at lower elevations and basin-wide pre-spawn mortality is variable depending on these physical parameters. Hatchery managers at traps and facilities can mitigate for some project effects through best management practices, which include reducing fish densities through frequent transport, decreased holding and handling, and monitoring for disease.

#### *3.8.1.6 North Santiam Sub-Basin*

USACE operates a system of two dams in the North Santiam. Operation of these structures have resulted in a decrease in the frequency and magnitude of floods, an increase in low flows (Riseley 2012), blockage of access for upstream migrating fish, and reduction in the survival and passage rates of downstream migrating fish (ODFW and NMFS 2011). Downstream, three diversion dams also exist affecting fish passage and stream flows to a lesser extent. The mean annual precipitation for the entire Santiam River basin is 78.2 in. (1971–2000) (U.S. Geological Survey 2012). River channels of the middle and upper reaches of the sub-basin are constrained.

The lower reach of the river, near the Willamette River confluence is mainly comprised of a wide, unconstrained flood plain. The economy of the Santiam River basin is supported by agriculture, timber harvesting, recreation, and manufacturing.

Approximately 70 percent of the basin is forested. Timber is harvested on both private, state and Federal lands. Higher elevation areas in the basin are managed by the Willamette National Forest. Forests have been altered by land use and historical logging (Dykaar and Wigington 2000), affecting the hydrology, reducing large wood within streams and rivers, and increasing sun exposure in some locations. Wildfires in recent years have significantly affected riparian forest areas above and below Detroit and Big Cliff dams. Despite these changes, the Santiam River variably provides adequate streamflow for fish and aquatic invertebrates (Wevers et al. 1992).

The North Santiam River supports diverse populations of anadromous and resident fish species and aquatic organisms. These fish species are a mix of native and non-native (i.e., introduced) species. There are many native resident fish species as well as several introduced species found in the North Santiam sub-basin. As discussed, large numbers of hatchery salmon and trout are released annually in the sub-basin. Only managed species or those with special status are discussed below due to the lack of data available on other native and non-native species in the sub-basin. Oregon Chub, recently delisted, is present in the Santiam sub-basin. Bull trout have been extirpated since the mid-1940's.

###### *3.8.1.6.1 Passage for ESA-listed salmonids and steelhead at Detroit Dam/Big Cliff Dam Complex*

Only adult hatchery origin UWR Chinook salmon are outplanted above Detroit Dam. These fish are collected at the Minto adult fish facility downstream of Big Cliff dam and transported by truck to spawn naturally in streams above Detroit Reservoir. To complete their migration to the ocean, juvenile progeny must pass downstream of Detroit Dam using the available spillway, the powerhouse or through regulating outlets. Survival through these passage routes is not considered adequately safe or effective under existing operations. More specific information on route specific survival and passage rates is included in appendix X (Fish Benefit Workbook inputs). Hatchery origin adult returns to Minto have met both broodstock and conservation needs in 60% of return years (ODFW & USACE 2016a). The hatchery affects to natural origin fish in the North Santiam vary with respect to disease transmission, introgression, and density-dependent predation and competition (NMFS & ODFW 2011). Pre-spawn mortality of adult Chinook salmon in the North Santiam is relatively low compared to other sub-basins, with the exception of 2015, a particularly dry year. Active building of Chinook redds occurs both upstream and downstream of Corps dams (Sharpe et al. 2018, Mapes et al. 2017). Passage and survival rates of juvenile Chinook through these routes under existing operations have not resulted in re-establishment of a sustainable population above the Detroit Dam, although female cohort replacement has been documented to exceed 1.0 for at least one brood year since 2008 (O'Malley et al. 2015).

Downstream passage at Detroit dam is not considered safe and effective. Therefore, currently unmarked (presumptive wild origin) UWR Chinook salmon and winter steelhead collected at the Minto Adult Collection Facility are outplanted below Detroit Dam by ODFW into a four-mile reach between Minto and Big Cliff dams. Emergency and contingency operations are in place particularly for dry years, and wild origin fish were outplanted above Detroit in 2015. Total dissolved gas between Minto and Big Cliff do exceed environmental thresholds (>110%) during flood control operations and there is concern that spawning fish and incubating eggs are negatively impacted during these periods of supersaturation. USACE manages TDG by releasing water from multiple outlets whenever possible (i.e., RO's, powerhouse, and spillway) and by spreading spill over multiple spill bays when possible.

In addition to operating the projects to achieve environmental flows (e-flows), the Corps uses controlled water releases to manipulate temperature for ESA-listed species downstream of Detroit Dam when reservoir elevation is above spillway crest. Willamette river basin temperatures tend to be too cool in the summer and too warm in the fall. This interim action dampens the downstream effects of non-normative temperatures on spawning fish and incubating eggs. These releases are effective during most of the year except during fall drafting, when only warmer surface waters are available for release. This results in winter water temperatures that are warmer than usual which may disrupt UWR Chinook salmon and winter steelhead spawning and migration and accelerate egg incubation and emergence timing.

###### *3.8.1.6.2 Hatcheries, wild salmon and steelhead in the North Santiam*

USACE's hatchery program in the North Santiam affects to natural origin UWR spring Chinook and winter steelhead vary but occur primarily through increased pHOS and increased risk of pre-spawn mortality. Currently pHOS below Minto ranges from ~60-70%. PHOS, and spawning distribution is not expected to change until actions are taken to increase abundances of wild spring Chinook salmon and winter steelhead or a reduction in abundance of hatchery spring Chinook spawners. USACE plans to continue annual monitoring to assess spring Chinook pHOS. Above Detroit Dam, only hatchery spring Chinook salmon are currently outplanted, so pHOS will be near 100% until passage is implemented. Implementation of the approved HGMP for the North Santiam allows integration of natural origin brood in order to reduce domestication effects associated with exclusive hatchery production upstream of Detroit Dam.

There are three areas where adult spring Chinook and winter steelhead spawn in the North Santiam sub-basin. Under existing fish passage conditions, there are limitations within each one.

Below Minto Trap (winter steelhead and spring Chinook salmon): NWFSC estimates this area contains just over 54% of the current usable spawning area for spring Chinook salmon in the sub-basin (Bond et al. 2017). Spawning success of natural-origin (NOR) fish is limited by a high proportion of hatchery-origin Chinook spawners (pHOS), effects of dam operations on flow, temperature and TDG. Just below Upper and Lower Bennett dams is the downstream extent of spring Chinook spawning due to high water temperatures in this lower elevation part of the watershed. Recent wildfires have severely impacted riparian and adjacent forest conditions in recent years, which may affect the quality of this habitat by increasing input of fine sediments to the stream and increasing water temperatures.

Big Cliff Dam to Minto Trap (winter steelhead and spring Chinook salmon): The NWFSC estimated this reach contains about 5% of the usable spawning habitat for Chinook in the sub-basin (Bond et al. 2018; see Table 1.5). This high gradient reach consists of falls, cascades, riffles and deep pools. Spawning success is assumed to be limited by the effects of dam operations on flow, temperature and TDG. Only natural origin spring Chinook and winter steelhead are outplanted between Minto and Big Cliff. Recent wildfires have severely impacted riparian and adjacent forest conditions in recent years, which may affect the quality of this habitat by increasing input of fine sediments to the stream and increasing water temperatures.

Above Detroit Reservoir in the Breitenbush and North Santiam rivers: Only hatchery spring Chinook are currently transported above Detroit Reservoir. NWFSC estimates these reaches contain 46% of the usable spawning habitat for spring Chinook. About half the spawning habitat for winter steelhead in the sub-basin is located above Big Cliff Dam (ODFW and NMFS 2011; see Table 6-6). Recent wildfires have severely impacted riparian and adjacent forest conditions in recent years, which may affect the quality of this habitat by increasing input of fine sediments to the stream and increasing water temperatures. Surface spill operations at Detroit Dam can increase passage and survival of downstream migrants, however the ability to provide spill in the spring and summer is unpredictable since it depends on winter and spring hydrology. Therefore, only hatchery origin spawners are outplanted to spawning habitat above Detroit dam except under contingency or emergency operations.

#### *3.8.1.7 South Santiam Sub-Basin*

Much like the North Santiam, the South Santiam is characterized by historically depleted riparian habitat. USACE operates a system of two dams in the South Santiam. Operation of these structures have included a decrease in the frequency and magnitude of floods (USGS 2012), impeded or blocked access for upstream migrating fish, and reduced survival and passage rates of downstream migrating fish (ODFW and NMFS 2011). Located downstream of WVS dams, Lebannon Water Diversion Dam affects stream flows to a lesser extent. The mean annual precipitation for the entire Santiam River basin is 78.2 in. (1971–2000) (U.S. Geological Survey 2012). River channels upstream of Corps dams are constrained, while the lower reach of the river is mainly comprised of a wide, unconstrained flood plain. Northern Pikeminnow, *Ptychocheilus oregonensis*) (Figure 3.8-10) are a primary predator but there is evidence that juvenile salmonids represent a smaller proportion of the diet. Phytoplankton abundance generally increases further downstream, primarily blue algae and diatoms (Altman et al. 1997).

In the South Santiam Subbasin, NWFSC estimated that about 59% of the usable spawning habitat for spring Chinook is located below Foster Dam, 30% above Foster Dam, and 10% above Green Peter Dam (Bond et al. 2018). The pHOS below Foster Dam for spring Chinook is very high, has a high potential to continue unless hatchery releases are reduced, in an effort to potentially positively affect the fitness and productivity of the naturally spawning population. For winter steelhead, research indicates substantial overlap in space in time of naturally produced winter steelhead juveniles and residual summer steelhead (Harnish et al. 2015). Introgression with hatchery summer steelhead is an ongoing impact for native winter steelhead in the sub-basin and Willamette Basin (Weigel et al. 2019a). Introgression associated with non-native steelhead above Foster Dam may also be introduced through the trap-and-transport program (Weigel et al. 2019b). The UWR Recovery Plan (ODFW and NMFS 2011) references 18% of the available spawning habitat for steelhead lies above Foster Dam.

**Figure 3.8-10. Northern Pikeminnow**

A passage program for spring Chinook and winter steelhead exists at Foster Dam. Downstream fish passage occurs using a combination of a weir and special spillway operations to support downstream passage of smolts and kelts. Due to concerns about collection efficiency of the original spillway weir, the Corps redesigned the structure to improve collection rates; however, the new weir saw higher injury rates, particularly for winter steelhead kelts. Upstream passage occurs using a trap and haul approach. Since cold water releases from Foster discouraged returning adults migrating upstream from entering the ladder at the Foster Adult Fish Facility, the Corps has reduced the effects of temperatures on adult collection rates using temporary actions for spill which also support juvenile passage downstream of Foster dam. USACE uses the weir to skim warm surface waters to encourage adults to enter the ladder. These solutions have been demonstrated to perform reasonably well. The wild population of spring Chinook salmon above Foster is considered self-sustaining. However, bull trout have been extirpated from the South Santiam. Currently, neither Chinook nor winter steelhead are transported above Green Peter Dam.

##### *3.8.1.7.1 Green Peter/Foster Dam Complex*

Historically, spring Chinook and winter steelhead were outplanted above Green Peter dam. A fish ladder and lift were used to transport adults, and a high head bypass system was used to pass juveniles downstream (USACE 1995). These passage systems were abandoned for several reasons. The fish ladder used deeper and cooler water from Green Peter, resulting in a temperature differential that discouraged adults migrating upstream from entering the fish ladder. Similarly, juveniles migrating downstream were not attracted to the entrance possibly due to poor flow cues near the entrance or conditions upstream in the reservoir. Last, predation rates from northern pikeminnow (*Ptychocheilus oregonensis*) were believed to be high in Green Peter Reservoir at the time (USACE 1995). Given the complications for up and downstream passage, both of these systems were ultimately abandoned. The NMFS 2008 Biological Opinion did not include passage at Green Peter in the RPA and recommended that jeopardy could be avoided by implementing passage at other projects, while research at Green Peter may be deemed necessary by NMFS at their discretion. A relict population of adfluvial (i.e., landlocked) UWR spring Chinook has been documented to successfully reproduce above Green Peter (Romer & Monzyk 2014). As progeny of hatchery origin outplants that were landlocked and successfully reproduced, this population is considered to be natural origin (see "Responses to Comments on the Draft EIS" in NMFS 2019).

Downstream of Green Peter and Foster, the Corps operates a trap and haul program to transport UWR spring Chinook and winter steelhead above Foster dam. Natural origin adults that enter the fish ladder at the Foster Fish Facility are outplanted near the head of Foster Reservoir or into upstream reaches. Hatchery origin fish that enter the ladder are not outplanted above the dam. Cold water from power peaking operations at Green Peter decreases ladder temperatures below Foster and can discourage adults from entering the ladder when temperature differences between the ladder and the incoming stream below the dam are too great. USACE is currently designing improvements to the fish ladder to increase temperatures and collection efficiency and uses temporary measures to ensure optimal ladder temperatures. In the past, juveniles migrating downstream do so through a removable spill weir. However, juveniles are now passed downstream using a special spill operation. USACE is currently investigating improvements to the weir design to decrease injury rates, particularly for winter steelhead; it also conducts a spill operation for downstream passage of juvenile Chinook, steelhead, and kelts at night whenever possible, in the meantime.

###### *3.8.1.7.2 Hatcheries, wild salmon and steelhead in the South Santiam*

The existing South Santiam Hatchery impacts natural origin spring Chinook and winter steelhead to varying degrees in the South Santiam with respect to disease transmission, introgression, and density-dependent predation and competition (NMFS & ODFW 2011). In recent years, pre-spawn mortality below Foster Dam has been lower than pre-spawn mortality above. The number of spring Chinook redds below Foster also exceeds the number of redds above (Sharpe et al. 2018); however, most production downstream of Foster is hatchery origin whereas only unclipped (and presumably natural origin) are outplanted above Foster. However, up to a third of presumably natural origin spring Chinook outplanted above Foster are of hatchery origin (Sharpe et al. 2018). Keefer et al. (2017) compared fish released in the reservoir to those released directly into the upper tributaries and found that reservoir-released fish experienced cooler temperatures. This may translate to lower pre-spawn mortality for these fish. However, the reservoir-released fish were also more likely to fall back over Foster Dam

(11% fallback rate). They hypothesized that these fallbacks may be volitional, as genetic analysis has found that up to 35% of transported fish do not originate from above Foster (Evans et al. 2016).

The NMFS 2008 Biop and the Upper Willamette River Conservation and Recovery Plan (ODFW and NOAA 2011) identify a goal of <30% pHOS for the entire South Santiam spring Chinook population and <5% pHOS for the entire South Santiam winter steelhead population. Below Foster Dam pHOS for spring Chinook ranges from ~60-90% (Sharpe 2015, 2016) due to the presence of the South Santiam Hatchery in the Foster tailrace and the transport of collected NOR fish above the dam. Above Foster pHOS for spring Chinook is low due to the transport of NOR fish above the dam. Routine monitoring is conducted to assess spring Chinook spawner abundance, distribution, pre-spawn mortality and pHOS.

#### *3.8.1.8 McKenzie Sub-Basin*

There are two dams operated by the Corps in the McKenzie Sub-Basin – Cougar Dam on the South Fork and Blue River Dam on the Blue River. Other dams in the sub-basin are operated by the Eugene Water and Electric Board, located along the mainstem McKenzie River. Those downstream from the Cougar and Blue River dams provide for fish passage.

The McKenzie is considered to contain the least degraded habitat among the Willamette River sub-basins, and e-flows are consistently met (Wallick et al. 2018). This is, in part, due to the fact that consumptive use (agricultural and municipal withdrawals) is less than in other sub-basins (Risley et al. 2010). Although the WVS here has retained more floodplain characteristics, flood flows and sediment transport have decreased (Risley et al. 2010). Bull trout populations existing in McKenzie and the Middle Fork (Altman et al. 1997, Zymonas et al. 2021).

The WVS in the McKenzie impacts ESA-listed UWR spring Chinook and bull trout primarily through blocked passage at Cougar Dam (the reach above Blue River dam did not historically support salmonids), changes to channel morphology, habitat degradation, and predation impacts on juveniles from the summer steelhead and rainbow trout stocking program. The McKenzie UWR spring Chinook salmon population is considered to be a “genetic legacy” population (NMFS & ODFW 2011). The full expression of Chinook juvenile life history migratory strategies has been documented in the McKenzie sub-basin (i.e., fry, sub-yearling, and yearling outmigrants) (NMFS & ODFW 2011). NWFSC estimates that about 11% of the usable spawning habitat is above the WVS dams in the McKenzie Sub-Basin (Bond et al. 2017).

ESA-listed bull trout occur throughout the McKenzie. The 2008 USFWS Biological Opinion determined that the continued operation and maintenance of the WVS would adversely impact bull trout critical habitat through impoundment, habitat fragmentation and a general decline in water quality (USFWS 2008). The recovery plan for bull trout identifies non-anadromous populations of UWR bull trout within the Coastal Recovery Unit (USFWS 2015). This unit includes populations in the McKenzie and Middle Fork sub-basins. The bull trout population in the South Fork of the McKenzie was formally considered a “genetic legacy” unit, but this delineation was revised in the last bull trout recovery plan (see USFWS 2015). Populations above the project appear to be isolated due to passage barriers and water quality (USFWS 2008, Ratliff and Howell 1992). Bull trout also require cooler temperatures and greater habitat complexity (Ratliff and Howell 1992), which may be in conflict with operations that target Chinook and steelhead life stages. The bull trout population above Cougar Dam has remained stable following reintroduction (Zymonas et al. 2021).

##### *3.8.1.8.1 Cougar Dam*

The construction of Cougar Dam blocked access to historic spawning and critical habitat for UWR spring Chinook and bull trout along the South Fork of the McKenzie River. Although the dam was built with up and downstream fish passage facilities, these were found ineffective and abandoned. A water temperature control tower was constructed in 2005 and allows for temperature management of discharged water downstream, particularly applied for UWR spring Chinook. An adult fish facility was also constructed in 2010 to collect upstream migrating adult spring Chinook and bull trout. Unmarked adult spring Chinook passed above Cougar Dam are supplemented with hatchery origin Chinook according to a hatchery genetic management plan (Corps and ODFW 2016). Pre-spawn mortality in returning adult Chinook above Cougar Dam is low (<10%), but is between 30% and 40% in the lower McKenzie River below Leaburg Dam. Downstream migrating fish must pass through existing routes, which include the regulating outlet or turbine penstocks. Passage and survival rates of juvenile Chinook through these routes under existing operations have not resulted in the re-establishment of a sustainable population above the dam (e.g., Sard et al. 2015).

##### *3.8.1.8.2 Blue River Dam*

There is no fish passage above Blue River Dam and there were no historic populations of anadromous salmon or steelhead above the project location. Today, the reservoir contains mostly stocked rainbow trout. Although effects are similar to those observed at other WVS projects, Blue River Dam operations have impacts on downstream habitats through regulated discharge (Risley et al. 2010). Similar to other WVS projects, controlled releases at Blue River Dam result in non-normative temperatures. With the exception of e-flows, the Corps has not conducted operations for temperature control at Blue River Dam.

##### *3.8.1.8.3 Hatcheries and Wild Salmonids in the McKenzie*

USACE's hatchery program in the McKenzie River affects natural-origin UWR spring Chinook salmon to varying degrees primarily through increased pHOS, and increased risk of pre-spawn mortality of the UWR spring Chinook. The NMFS 2008 Biological Opinion and the Upper Willamette River Conservation and Recovery Plan (ODFW and NOAA 2011) identify a goal of <10% pHOS for the McKenzie sub-basin spring Chinook population. Currently pHOS both below Leaburg and above Cougar ranges from ~70-90%. Routine monitoring is conducted to assess spring Chinook spawner abundance, distribution, PSM and pHOS. PHOS, and spawning distribution, may not change until actions are taken to increase abundance of wild spring Chinook or reduce abundance of hatchery spring Chinook spawners. Returning adult hatchery Chinook are either collected at McKenzie or Leaburg Hatchery, trapped and removed by hand from the Leaburg Dam fish ladder by ODFW, trapped at Cougar Dam adult fish facility, or spawn naturally in the McKenzie River or its tributaries.

ODFW maintains a summer steelhead program exclusively for harvest opportunities, per contract. The McKenzie is not part of the winter steelhead DPS and summer steelhead do not directly impact reintroduction efforts.

#### *3.8.1.9 Middle Fork/Coast Fork Willamette River*

The Willamette River originates in the Middle and Coast Forks (Altman et al. 1997). ESA-listed spring Chinook salmon and bull trout, as well as Oregon chub, (delisted in 2015) are present in the Middle Fork Willamette (MFW) sub-basin. The four projects (Dexter Dam-DEX; Lookout Point Dam—LOP; Hills Creek Dam—HCR; Fall Creek Dam—FCR) in the Middle Fork form a complete barrier to upstream fish passage, requiring adult fish facilities at the base of DEX and FCR dams that are used for collection of hatchery brood and/or transport of adult Chinook upstream. The older adult collection facility at DEX does meet NOAA fish passage guidelines, and a new facility is currently being designed. A new adult fish facility was completed at Fall Creek Dam in 2018. NWFSC estimates about 65% of the usable spawning habitat for Chinook is upstream of LOP Dam, 24% above HCR, and about 3% above Fall Creek.

ODFW began transferring excess hatchery-origin adult spring Chinook Salmon above DEX and FCR in 1993. The NMFS 2008 Biop included continuation of this program as an experimental aide to Chinook salmon reintroduction, including above HCR. Since 2009, only unmarked Chinook salmon have been transported above Fall Creek Dam due to operational changes providing for improved downstream passage (as discussed below), and leading to a sustainable population above Fall Creek Dam. Naturally produced juvenile offspring migrate into these reservoirs annually (Romer et al. 2013).

The WVS in the Middle Fork affects ESA-listed spring Chinook salmon and bull trout and has blocked passage along several reaches. Other impacts include altered hydrology and water temperatures and habitat degradation through blocked access to spawning grounds by inundation of headwaters. The accessible reach of the Middle Fork is lower in elevation than the other three sub-basins, and typically experiences high temperatures where returning adult fish hold below dams prior to moving upstream to spawn. This contributes to high rates of pre-spawn mortality and predation rates in project reservoirs. Furthermore, habitat degradation downstream of Corps projects may not provide suitable rearing habitat for juvenile Chinook. In its evaluation of alternatives to address the NMFS 2008 RPA, USACE identified the Middle Fork as having the greatest uncertainty around establishing a sustainable population above DEX, LOP and HCR dams due to high adult pre-spawn mortality, high juvenile mortality in reservoirs and uncertainty around adequate downstream passage solutions (USACE 2015).

##### *3.8.1.9.1 Lookout Point/Dexter Dam Complex*

Adult Chinook are collected below Dexter Dam at an outdated facility optimized for collection of hatchery broodstock in conditions where temperatures and densities of hatchery origin fish are high, contributing to high rates of pre-spawn mortality (Bowerman et al. 2018). The NMFS 2008 Biological Opinion RPA recommended that the facility below Dexter Dam be updated (NMFS 2008). Currently, designs for a new adult facility are being completed.

The combined length of Lookout Point Reservoir and Dexter Pool is about 20 linear miles, creating a challenge to downstream migrants. Recent research has estimated high reservoir mortality of juvenile spring Chinook (Kock et al. 2019). This is expected in part to be due to predation (Brandt et al. 2016).

Several alternatives have been examined to evaluate downstream passage in the Middle Fork, particularly at Lookout Point Dam. In 2010, AECOM completed a feasibility study of in-tributary, mid-reservoir, and at-dam passage solutions for Lookout Point Dam. The study concluded that several uncertainties were associated with the Middle Fork that precluded a decision point for Middle Fork Passage (AECOM 2010). In 2011, a follow-up study by AECOM indicated that a head of reservoir collector could improve downstream passage but was technologically complicated and would require the construction of new dams at collection points (AECOM 2011). A study by the University of British Columbia (2020) similarly concluded that while a head of reservoir collector could prove beneficial, the risk to population viability if the collector could not perform or if downstream habitat was not available to fry, were much higher than at-dam solutions (McAllister et al. 2020).

##### *3.8.1.9.2 Hills Creek Dam*

HCR Dam blocks access for spring Chinook to historic salmonid habitat. A reintroduced population of bull trout existing above the dam has grown significantly and steadily over nearly the last decade (Zymonas et al. 2021). The bull trout population spawns in tributaries to Hills Creek Reservoir and rears and forages in upstream tributaries and within Hills Creek Reservoir. Periodically hatchery spring Chinook salmon are translocated by truck above the dam for the purposes of research. There are no fish passage facilities at HCR. Downstream migrating fish must pass through existing routes which include the regulating outlet and turbine penstocks. Rigorous study of passage rates and survival rates for downstream passing fish has not be conducted at HCR Dam, but are assumed to be similar to Cougar Dam based on results from rotary screwtraps reported by Larson (2000) and Keefer et al. (2013).

##### *3.8.1.9.3 Fall Creek Dam*

FCR Dam on Fall Creek (river mile 7.9) was completed in 1965. Only wild ESA-listed spring Chinook salmon return to the adult trap. A new Fall Creek adult trap was completed in 2018 and downstream passage is achieved by a deep drawdown to streambed in late November or early December, annually, which allows juvenile Chinook and other fish to safely and effectively exit downstream through lower outlets. Successful passage operations have resulted in a sustainable population of UWR Chinook above Fall Creek to be re-established; however, the effective population size of genetic contributors remains small (O'Malley and Bohn 2018) and has demonstrated variable pre-spawn mortality (Bowerman et al. 2018). Due to the small effective population size, survival of their progeny to adulthood is assumed to be relatively high. Most juveniles enter Fall Creek Reservoir in February and March after emergence, and then rear until the fall reservoir draft. After rearing between spring and fall annually, spring Chinook juveniles achieve an exceptional size in Fall Creek Reservoir. This size at emigration is likely contributing to adult survival rates, as observed in other Chinook populations. Pre-spawn mortality research is ongoing to elucidate the factors driving pre-spawn mortality and a post-construction evaluation of the newly constructed trap is ongoing. In 2020, adult returns exceeded 800 individuals; well, above the historic estimate for this population despite high pre-spawn mortality (WFPOM team meeting minutes, October 28, 2020).

There are no hatchery origin spring Chinook translocated above Fall Creek Dam. The population is sustained by transport of natural origin adult Chinook upstream annually.

#### *3.8.19.4 Hatcheries and Wild Chinook Salmon in the Middle Fork*

USACE's hatchery program in the Middle Fork Willamette River affects natural origin UWR spring Chinook to varying degrees primarily through increased pHOS at low elevation, increased risk of pre-spawn mortality, and increased fish transport delays. With the exception of above Fall Creek Dam, production of natural-origin Chinook salmon is at extremely low levels in the Middle Fork. A portion of hatchery production mitigation is currently released in the Coast Fork Willamette to support sport harvest opportunities, but these juvenile Chinook salmon are limited by poor rearing conditions and are not considered viable.

Adult hatchery-origin Chinook salmon are transported above Lookout Point Dam and Hills Creek Dam to increase production in the Middle Fork, provide foraging opportunities for bull trout above Hills Creek Dam, support fish passage and pre-spawn mortality RM&E, and support re-establishing a sustainable natural population in the Middle Fork. Between 2002 and 2015, the number of adult hatchery Chinook salmon transported annually above Lookout Point Dam ranged from 555 to 3,765, and from 0 to 3,328 above Hills Creek Dam. In the last 7 years, the number transported above each of these dams ranged from approximately 1,000 to 2,000 annually. Since fish passage conditions are poor, with natural return rates well below those needed to achieve a cohort replacement rate of $\geq$ 1, mostly hatchery-origin adult Chinook salmon will continue to be outplanted above Dexter Dam until fish passage conditions improve.

Prespawn mortality rates continue to remain at moderate (>25%) to high (>50%) levels for adult Chinook salmon trapped and transported from the Dexter Dam adult trapping facility (Sharpe et al. 2016). Keefer et al. (2010) modeled adult Chinook salmon returns, varying the pre-spawn mortality rates across the range of observed rates, and holding juvenile and ocean survival rates constant. They concluded that "unless juvenile survival is exceptionally high, the North Fork (Middle Fork) population model results indicate that the high pre-spawn mortality rates we recorded in some years are likely to have a significant negative effect on reintroduction efforts and establishment of self-sustaining populations".

The abundance of hatchery-origin Chinook salmon on the spawning grounds may influence pre-spawn mortality above Lookout Point Dam. Currently only hatchery-origin adults are outplanted due to the very low number of natural-origin (unmarked) Chinook salmon returning to Dexter Dam. These fish do not originate in the habitat above Lookout Point Dam, which may reduce their propensity to spawn naturally. However, this seems unlikely given that pre-spawn mortality rates for hatchery and natural origin adult Chinook salmon are very similar above Santiam dams and above Cougar Dam in the McKenzie in recent years (e.g., Sharpe 2016 WFSR presentation). Pre-spawn mortality has also been linked to how quickly females are able to establish redds once on the spawning grounds (Hruska et al. 2011), again suggesting that the duration of exposure to high temperatures at high spawner densities may increase pre-spawn mortality rates.

USACE's hatchery program is implemented to meet mitigation obligations and ESA requirements. There are varying degrees of negative impacts of hatchery production on wild origin fish. NMFS determined these impacts to be negligible in light of the fact that wild origin fish lack sufficient passage (both upstream and downstream) around the dams and reservoirs to be self-sustaining. Nonetheless, at current production levels, the hatchery program will likely result in increased impacts to the Corps' ESA mission without reevaluation and adaptive adjustments to decrease population level impacts to UWR spring Chinook salmon and winter steelhead as passage is improved.

### 3.8.2 Environmental Consequences

This section describes the analytical approaches used to evaluate UWR spring Chinook and winter steelhead. The population models each produce the performance metrics while the sub-models are treated as inputs to the population models. Non-salmonid species are evaluated qualitatively as described in the Methodology. In this section of the PEIS, duration (length of time that an effect lasts) and extent (geographic area over which the effect occurs) are not explicitly identified under each of the predicted effects because this would be unnecessarily repetitive. For each alternative, the duration of effects would be the entire period of study to 2050 and the extent would be the entire sub-basin under discussion.

#### *3.8.2.1 Methodology*

The area of analysis for aquatic species and ESA-listed resources is defined broadly as the geographic boundaries of the WRB. The Willamette River is located entirely within the state of Oregon, beginning south of Cottage Grove and extending approximately 187 miles to the north where it flows into the Columbia River.

This Draft PEIS evaluates fish and aquatic habitat using a quantitative (ESA-listed salmon and steelhead and critical habitat) and qualitative (bull trout and habitat) framework. The quantitative framework relies on output from a suite of models developed for ESA-listed salmon and steelhead. This process is similar to the quantitative and peer reviewed process of Ensemble modeling. This approach typically involves using multiple models to come to a more informed management decisions given the known limitations and advantages of each model. While broadly applied in many disciplines, it has not been implemented for UWR salmon or steelhead for the purpose of describing biological benefits and impacts from hydrosystem management. Ideally, each model should cover a spectrum of assumptions about the system that the others do not. In this way, risks and consequences of each assumption are explicitly exposed and transparent to process participants. The EIS process does not require the use of multiple models; however, the process greatly benefits from the exercise and informs an overall better- decision based on tradeoffs.

USACE utilized three population models to assess ESA-listed salmon. The Ecological Diagnosis Treatment (EDT) model was developed through the collective efforts of many biologists, modelers and users in over two decades to assess effects of management actions on habitat conditions, fish abundance, and distribution, including the impact of hatchery management strategies on ESA-listed fish and fishery objectives. The University of British Columbia has developed a Bayesian Integrated Passage Assessment (IPA) approach which uses prior probability distributions (i.e., prior information) to inform abundance trends based on a portfolio of proposed management operations and fish passage structures. In contrast to the other two models, the IPA model only accounts for the performance of populations above WVS dams. Lastly, the NOAA Life Cycle Model has previously been used to analyze management action benefits to salmon and steelhead for the Corps' Configuration and Operations Plan (USACE 2015). The details of these models are described in the Effects Analysis Section.

These three approaches cover a broad spectrum of assumptions and utilize a range of frameworks from deterministic to probabilistic approaches. The use of three models promotes explanation of contrasting results that must be explained by a) the range of assumptions of each model, and b) the risks associated with each wrong or incomplete assumption. By comparing these results, assumptions and consequences are explicitly exposed. Those weaker assumptions that are of smaller consequence to participants may be preferred over model assumptions that carry higher consequences if wrong. In this way, the process becomes more transparent to participants, which instills objectivity in the EIS process. In the description that follows, each population model is supplemented where data are scarce or where management operations have never previously been attempted. These include the Fish Benefits Workbook to describe dam passage and a flow-survival model to characterize downstream responses to flow management.

Each model predicts aspects of the NOAA Viable Salmonid Population (VSP) framework (McElhaney et al. 2000). A VSP is one that meets threshold criteria for spatial structure, diversity, productivity, abundance, and risk of extinction. To maintain consistency with how NOAA evaluates project actions, explicit consideration of VSP is the evaluation framework for this Draft PEIS. Each of the VSP metrics are weighted based on performance, availability of data, and the quality and availability of data. In general, higher VSP scores indicate greater viability. VSP scores are calculated from the output of salmonid population models. These models tend to cover all or most of the salmonid life cycle. Most information comes from the hydrosystem because the ocean phase of the life cycle is less understood. Although VSP is used to evaluate salmonid population resilience, this analysis considers additional criteria specific to USACE. First, USACE must explicitly consider aspects of the hydrosystem that it most affects such as downstream passage and downstream water quality effects. Though not an explicit VSP consideration, these metrics are also considered in the suite of effects analysis models. Second, while VSP describes the viability of a salmonid population, USACE considers replacement potential (i.e., whether each generation produces enough juveniles to at least replace itself) to mitigate for the effects of the project without consideration of factors outside of its authority to address (e.g., ocean conditions). Table 3.8-9 summarizes the metrics produced in this analysis.

**Table 3.8-9. Summary effects analysis metrics for ESA-listed UWR spring Chinook and winter steelhead**

| Primary attributes | Description | Primary data sources sought | Units of measure |
|---|---|---|---|
| Productivity | Population Growth Rate | Recruits/Spawner (R/S), Smolt-to-adult-return rates (SAR), counts or indices of abundance for adults and juveniles | Estimated change in the geometric mean R/S, SAR, and A/P |
| Abundance | Geomean of naturally producing adults | Empirical counts, retrospective analysis, and simulations of adult return counts and redds | Estimated trends in geomean abundance of natural origin spawners over several salmon generations (forecasted period will depend on data available to support given expected uncertainty of prospective analyses) |
| Extinction Risk | Quasi extinction risk (QET) | Empirical counts and prospective analysis of adult return counts and redds | Probability that abundance is less than threshold over several salmon generations (forecasted period will depend on data available to support given expected uncertainty of prospective analyses) |
| Diversity | Number of surviving trajectories | Life history strategies that survived under a management alternative | Proportion of surviving life history strategies |
| Bull Trout Habitat | Increase in bull trout habitat | The amount of habitat and relative risk that is improved under an alternative | Percent increase over the No Action Alternative |

The primary performance metrics (Table 3.8-9) for the population models are: 1. Equilibrium abundance which describes the adult abundance predictions once the population stabilizes at some point in the future (30-100 years), 2. Productivity describes the number of successful juveniles that are produced per adult spawner either in the first 10 years or as an average over 100 years, 3. Extinction Risk is the probability that a population will fall below a given number of adults at some point into the future (30-100 years), 4. Diversity is the percentage of life history strategies that succeed (i.e., demonstrate a productivity greater than 1) once the population reaches equilibrium (5-10 years), and 5.Bulltrout metrics include: the increase in rearing and foraging habitat access and the risk of exposure to limiting factors (5-10 years). The performance metrics inform the evaluation criteria (Table 3.8-10).

The performance metrics 1-4 describe salmonid viability. Impacts are characterized by whether or not a given population is "viable" or "not viable" for a given performance metric. The alternatives are evaluated based upon: 1. The number of populations that have a low extinction risk, 2. The number of populations that demonstrate a productivity (i.e., recruits per spawner) close to or greater than 1.0 (i.e., whether or not the population is able to replace itself), and 3. Whether or not the McKenzie Core Legacy population is likely to go extinct. If any one of these criteria is not met, then the population is at risk according to the impact description below (Table 3.8-10). The EDT output: Diversity, productivity, and equilibrium abundance are ranked in terms of performance in a given water year type (wet, dry, and normal). A lower ranking indicates a better performance. If the water years receive the same ranking, it is an indication that the alternative is robust to differences in annual hydrology. If water years receive different rankings, it is an indication that the alternative is sensitive to changes in hydrology.

**All comparisons of effects for each action alternative are in comparison to the NAA unless stated otherwise.**

**Table 3.8-10. Evaluation Criteria for Potential Effects for Spring Chinook and Winter Steelhead**

| Effect Scale | Criteria |
|---|---|
| None/negligible | Sub-basin extinction risk during the period covered by this PEIS would be very low (<1%). Maximum productivity would be greater than 1; equilibrium abundance would be above the levels recommended to sustain the population. For Chinook, 3 of 4 populations would persist and at least one of those populations would include McKenzie, a Core Legacy population. For steelhead, both populations in the North and South Santiam would persist. An alternative that demonstrates negligible effects in these categories is considered to MEET THRESHOLDS for viability. |
| Minor | Sub-basin extinction risk would be low (>1%≤5%). Maximum productivity is greater than 1; equilibrium abundance would be above the levels recommended to enable recovery. For Chinook, 3 of 4 populations would persist and at least one of those populations include McKenzie, a Core Legacy population. For steelhead, both populations in the North and South Santiam would persist. An alternative that demonstrates minor effects in these categories is considered to meet all thresholds for viability. |
| Moderate | Sub-basin extinction risk would be moderate (>5%<10%. Maximum productivity would be near 1; equilibrium abundance would be above the levels recommended to enable recovery. For Chinook, 3 of 4 populations |

| Effect Scale | Criteria |
|---|---|
| | would persist at the moderate extinction level and at least one of those populations would include McKenzie, a Core Legacy population. For steelhead, both populations in the North and South Santiam would persist. Mitigation measures would be necessary and would reduce potential adverse effects. An alternative that demonstrates moderate effects in these categories is considered to meet most thresholds for viability. |
| Major | Extinction risk would be high (>10%). Maximum productivity would be less than 1; equilibrium abundance would be below the levels recommended to enable recovery. For Chinook, less than 3 populations persist and would not include McKenzie, a Core Legacy population. For steelhead, less than 2 populations would persist. Mitigation measures to offset the adverse effects may be required in accordance with Corps policies to reduce effects from long-term changes to the resource. An alternative that demonstrates major effects in these categories meets few or no thresholds for viability. |

The qualitative approach for aquatic resources and aquatic habitat uses a weight of evidence approach, that is, while there is no quantitative analysis, conclusions may be reasonably drawn from multiple sources of information in the peer reviewed literature. Many of the habitat attributes considered by EDT can also inform habitat quality over the Alternatives.

In this section of the Draft PEIS, duration (length of time that an effect lasts) and extent (geographic area over which the effect occurs) are not explicitly identified under each of the predicted effects because this would be unnecessarily repetitive. For each alternative, the duration of effects would be the entire period of study to 2050 and the extent would be the entire sub-basin under discussion.

##### *3.8.2.1.1 Population Model 1: Ecosystem Diagnosis and Treatment (EDT)*

EDT is an approach to decision analysis that provides information on population performance under any number of habitat conditions. The tool was developed to account for continuity and quality of habitat under alternative management strategies, particularly in riverine environments. Lestelle et al. (2004) provide a comprehensive overview of EDT and its application to most Pacific salmon species. In brief, the approach is driven by fish capacity (the number of fish that can be supported by the habitat) and productivity (benchmark survival) at each life stage. The total population capacity and productivity is then the integration over all life stages such that habitat quality is accessible at varying time and spatial resolutions (Lestelle et al. 2004). This latter point is of relevance for anadromous fish management where conditions in the freshwater environment impact specific life stages. These impacts must be known both at the life-stage and population levels to inform decision-makers.

EDT has been used to inform decisions on salmon management in the Chehalis River system (ENVIRON International 2011), the Interior Columbia Basin (Wooster et al. 2019), and the Puget Sound (Paquet et al. 2011). The approach utilizes an underlying basin geometry using Geographic Information Systems (GIS) and overlays habitat attributes that may impact a benchmark survival of a fish in a given reach at a given life stage. Fish may have numerous life history pathways or "trajectories" that they express under a given set of habitat attributes (ICF 2019). Habitat attributes are linked to the expression of life history trajectories through a Beverton-Holt stock-recruitment function (i.e., the number of juveniles expected to survive to adulthood given the number of adult parents that produced them and their intrinsic productivity) (Figure 3.8-11).

The trajectories that successfully navigate the basin geometry to complete their life cycle, given the habitat attributes that exist or are proposed to exist (e.g., downstream passage solutions) contribute to "persistence." Life history trajectories that persist contribute to the population performance (e.g., productivity, capacity, equilibrium abundance) (Figure 3.8-11). EDT does not aim to predict abundance as a statistical model would but predicts the abundance that the population may be expected to replace itself in the next generation given the habitat conditions (Figure 3.8-12) that exist, i.e., at what abundance a population may be considered stabilized given the management actions implemented.

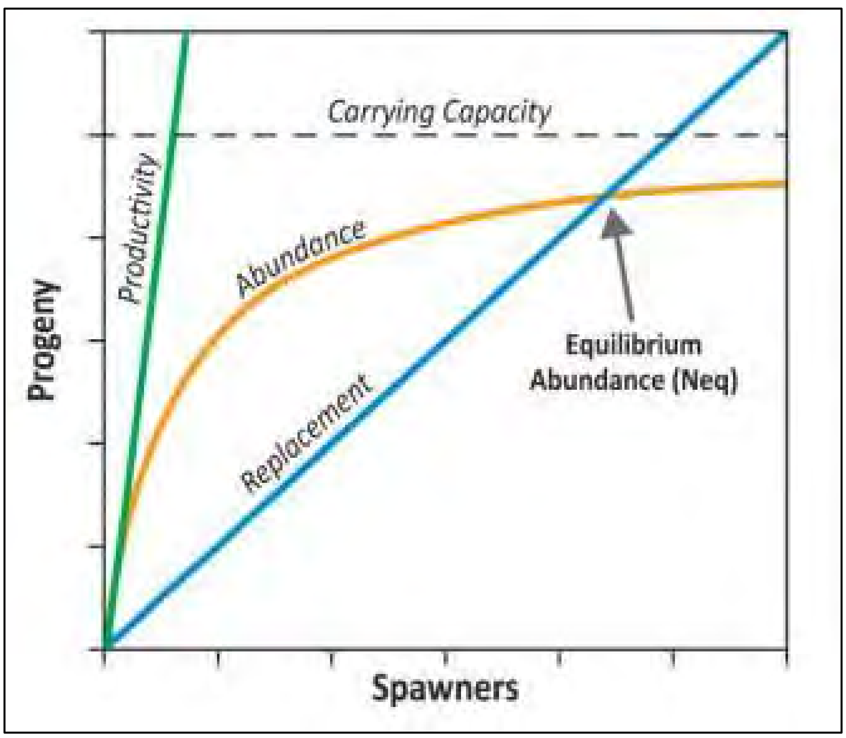



**Figure 3.8-11. Attributes of a Beverton-Holt function**

Note: Figure adapted from ICF (2019). EDT predicts equilibrium abundance (i.e., replacement) given the carrying capacity under a set of habitat attributes and the productivity (i.e., the number of juveniles per spawners at low abundance).

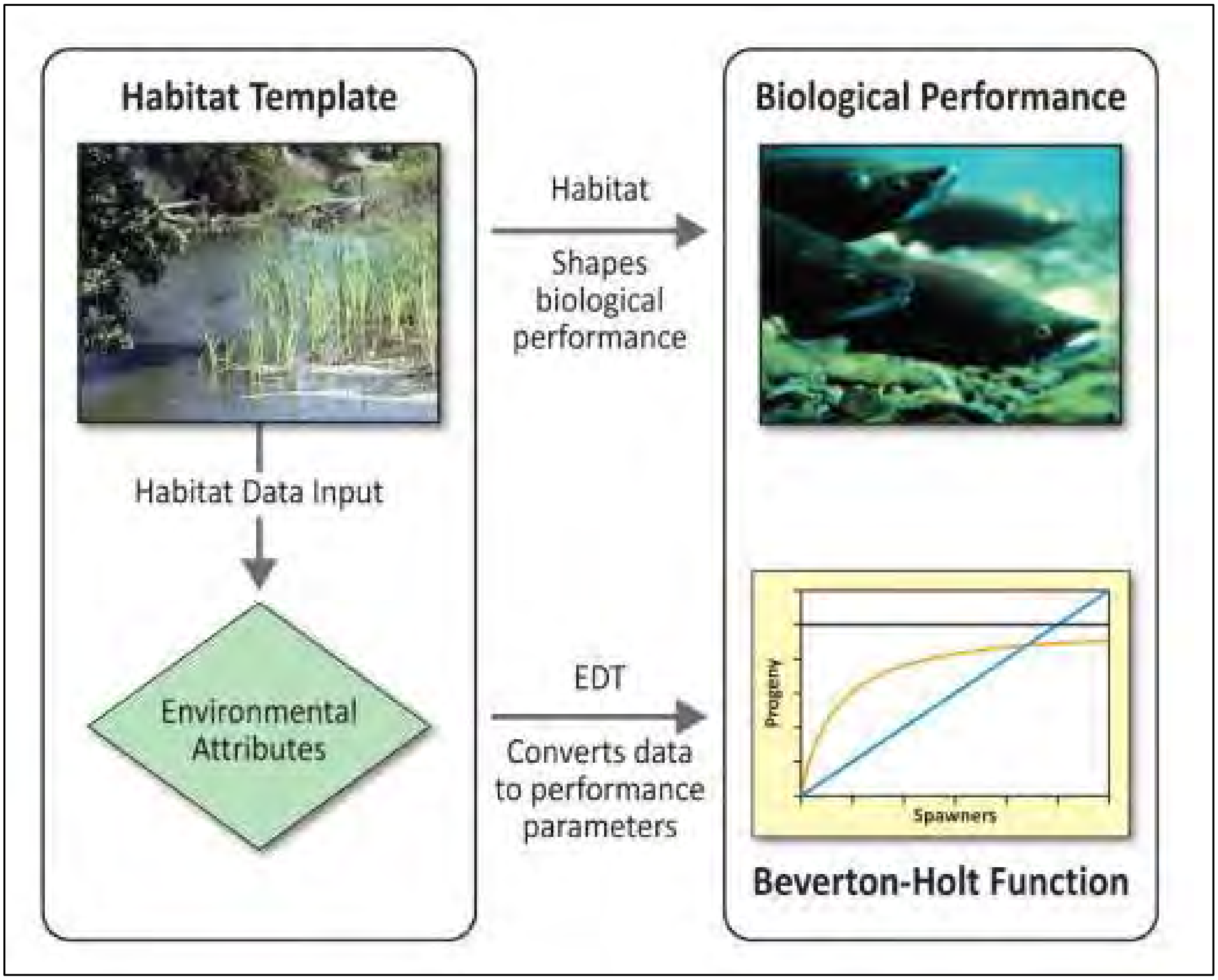



**Figure 3.8-12. A conceptual overview of the EDT process. Figure adapted from ICF (2019).**

There are several key assumptions in this modeling approach:

Modeled changes in temperature, flow, fish passage, etc. reflect habitat quantity/quality differences between current conditions and alternative scenarios under different water year conditions.

Abundance, capacity, productivity, and diversity are primary EDT outputs.

Differences in physical habitat (width and depth of reaches; spatial extent of reservoirs) between scenarios was not explored in this exercise.

##### *3.8.2.1.2 Population Model 2: Integrated Passage Assessment (IPA)*

The IPA framework describes three goals: to describe a passage action evaluation for ESA-listed spring Chinook salmon and winter steelhead, to determine how well each of the proposed alternatives meets management objectives, and to develop an analytical framework that can address uncertainty. The IPA uses several operating models within the same framework. Each operating model has been previously developed for similar applications but have been refined to support the Draft PEIS. These are: the NOAA Life Cycle Model, the Corps' Fish Benefit Workbook, and the Oregon State University flow-survival model/structured decision analysis. Each component model is used to inform evaluation of the alternatives (Figure 3.8-13).

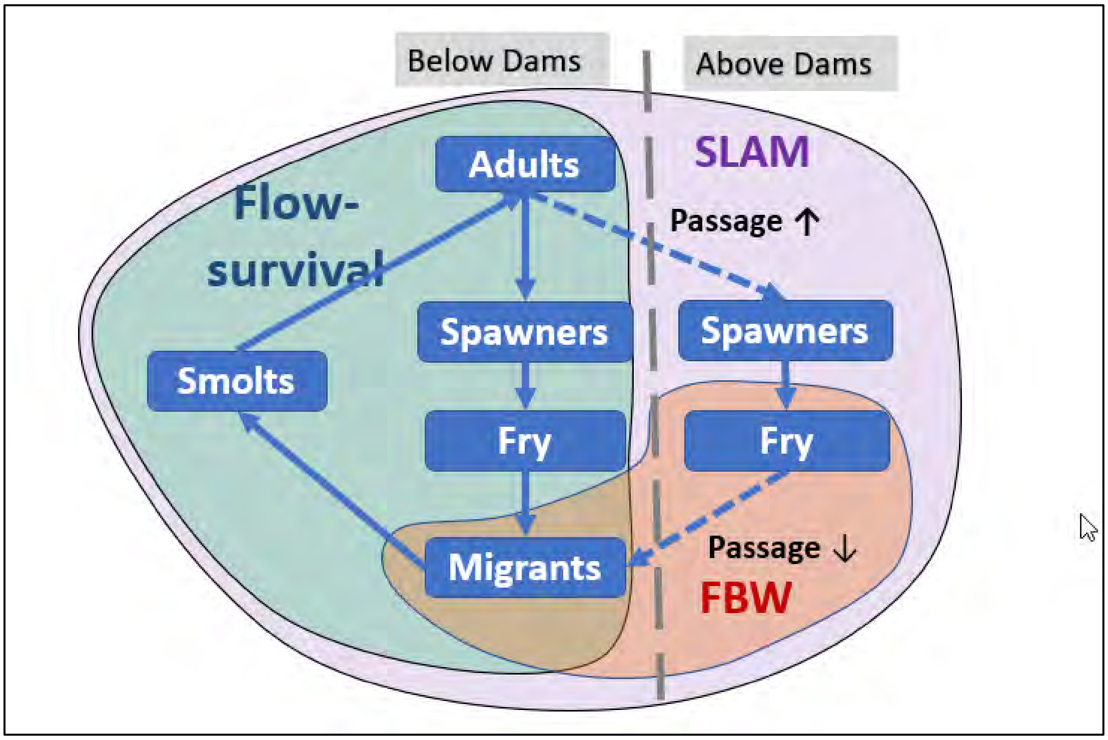



**Figure 3.8-13. Conceptual overview of the Integrated Passage Assessment Model**

Note: The IPA uses attributes of existing models to characterize aspects of the hydrosystem with respect to passage actions. Figure adapted from the UBC Integrated Passage Assessment presentation given at the EIS Cooperators Meeting February 10, 2021.

Using information from these models, the IPA includes an apparent survival (mark-recapture) model to inform survival within a reach of interest. The reaches are representative of habitat above dams, downstream dam passage, downstream habitat conditions, ocean conditions, and upstream migration. Survival in one reach implies transition to the next and the survival probabilities in each reach are estimated simultaneously (Figure 3.8-14).

$$\text{Reservoir} \xrightarrow{S_1} \text{Dam} \xrightarrow{S_2} \text{Lower River} \xrightarrow{S_3} \text{Ocean} \xrightarrow{S_4} \text{River}$$

**Figure 3.8-14. The Integrated Passage Assessment considers how conditions may influence survival in five broad reaches**

Note: The probability of survival in each reach is estimated simultaneously. Figure adapted from the UBC Integrated Passage Assessment presentation given at the EIS Cooperators Meeting February 10, 2021.

Fry-adult survival and productivity are informed by using existing telemetry data to generate a survival and detection probability for each reach and integrating over all reaches. Where data are scarce or unavailable, these estimates can be driven by “prior” information. In this context, “prior” information can be based on information from other similar systems, accepted peer reviewed research, or scientific intuition. Computer routines allowing prior information then allow the user to simulate different management scenarios thousands or even millions of times to reasonably predict an outcome. This is the mechanism that allows for explicit estimation of *survival and the degree of uncertainty about the prediction*. The goal of this approach is not only to arrive at a number but to also describe how certain the estimate is given the available data and prior knowledge. To capitalize on this quantitative information about uncertainty, the integrated passage model includes a structured decision-making process, whereby data gaps are easily identified and described in terms of relative importance. For example, growth rates may not be precisely known for a given reach at a given time but may be of less consequence than not having data on the availability of juvenile rearing habitat to support growth. Therefore, while growth may not be precisely known, information about available habitat to support growth may be of greater relevance to, and could have greater impact on, the outcome. This would not be known without explicitly quantifying the amount of uncertainty in several dimensions. In this way uncertainties, and their relative importance across time and space, can be integrated over all reaches to describe the confidence around a given passage action to provide biological benefit.

The IPA provides several performance metrics for juvenile and adult life stages. Importantly, it predicts productivity, which is defined as the number of surviving juveniles per successful parent spawner. Productivity is measured at low abundance i.e., when the population would be expected to demonstrate maximum growth rate following a management action. This metric allows decision makers to know how productive a given population will be. The second important performance metric is the equilibrium abundance, or the abundance at which the population is stable and not significantly increasing or decreasing annually. Lastly, the quasi-extinction risk (QET) is simply the probability that the population will be above a population abundance threshold number for the duration of given management actions (2020 – 2050).

There are several key modeling assumptions that must be made using this approach:

The model considers only above dam populations, i.e., those populations directly impacted by blocked passage.

The model only considers the length of the proposed management action (28 years into the future).

Egg-fry survival rate as a function of eggs deposited and follows a Beverton-Holt function.

There are six juvenile migrant types above dams within three main groups (fry, fall subyearlings, yearlings).

Reservoir survival rate of juveniles is invariant to the downstream dam passage measure applied.

Splits for juvenile migration groups above dams are invariant to downstream dam passage measure applied.

In two-dam models juveniles originating above and passing down through Hills Creek and Green Peter will try to pass directly through downstream dams without stopping.

Dam passage survival and dam passage efficiency were bootstrapped from fish benefits workbook.

Future marine survival reflects historical variation in early ages (to age-3) marine survival.

At sea fishing mortality rates and incidental mortality rates in terminal fisheries from CTC 2021 mortality rate assessment approximate long-term average mortality rates.

Upstream passage has 100% survival.

Spawning success of hatchery origin fish is less than natural origin fish.

Juvenile reservoir survival does not change under different management scenarios.

The telemetry data used to predict downstream survival is representative of long-term averages.

The proportion of adults in each age class remains the same in the ocean phase of the life history.

Previously measured harvest rates are representative of the long-term average.

Juveniles can depth compensate during periods of high TDG.

###### *3.8.2.1.3 Population Model 3: NOAA Life Cycle Model (LCM)*

The NOAA LCM uses multiple sources of information to characterize downstream emigration, ocean survival, and upstream migration of spring Chinook and winter steelhead (Myers et al. 2018). The LCM is characterized by a number of phases, splits, life history variations, and origin (wild steelhead and Chinook and hatchery Chinook). Juveniles will die or leave the hydrosystem based on a number of factors. As they enter the ocean, several factors impact their successful navigation back to the river to spawn in their natal stream and contribute to overall production of their Evolutionarily Significant Unit (ESU; spring Chinook) or Designated Population Segment (DPS; winter steelhead). The overall status of the ESU or DPS is the basis for determining viability. NMFS describes the viability of a species using the Viable Salmonid Population (VSP) metric (McElhany et al. 2000). The VSP metric considers several aspects of population performance (abundance, productivity, diversity, and spatial structure) that the LCM attempts to predict.

While the LCM is initiated using returning adults, it is helpful to consider the model description starting from the juvenile stage. It is assumed that a proportion of deposited eggs will survive to emergence in the spring. Juvenile fish above dams enter a reservoir based on timing information from empirical data such as telemetry, information from similar systems, or justifiable hypotheses based on historic observations (ref). It is assumed that reservoir rearing juveniles are subject to some degree of reservoir mortality, which again is either hypothetical or informed by empirical data when available (e.g., Kock et al. 2019). As fish approach the dam, their availability to pass, passage effectiveness, and survival is determined using prescribed passage measures in the Fish Benefit Workbook (see section 3.10…). Fish passage and timing is determined by the proposed passage action and an emigration life history type. For spring Chinook, these are broadly characterized as spring fry, fall sub-yearlings, or spring yearlings. For winter steelhead, the life history types are sub-yearlings, yearlings, and age 2 juveniles (Malone et al. 2014). In general, survival upstream of a given dam is characterized by emergence, movement into the reservoir, and availability of fish to pass. Each of these components are informed by empirical data where it exists, justifiable hypotheses, or historical information.

The LCM then posits that survivors that have passed the dam are subject to mortality factors such as total dissolved gas (TDG). Below Willamette Falls, juveniles become smolts and enter the ocean at age 2. Upon ocean entry, several outcomes are possible. A spring Chinook adult can be removed by harvest, die, return to the river, or remain in the ocean as a four, five, or six-year-old. Similarly, winter steelhead can return as a three, four, or five-year-old. For fish that return to the river to spawn, they are subject to a number of mortality factors including harvest and pre-spawn mortality (PSM). Returning adults are allocated to their natal stream based upon the proportions of juveniles that left as emigrants. A proportion of winter steelhead outmigrate as kelts (a spawned fish) and may return as repeat spawners. The LCM is represented conceptually in Figure 3.8-15.

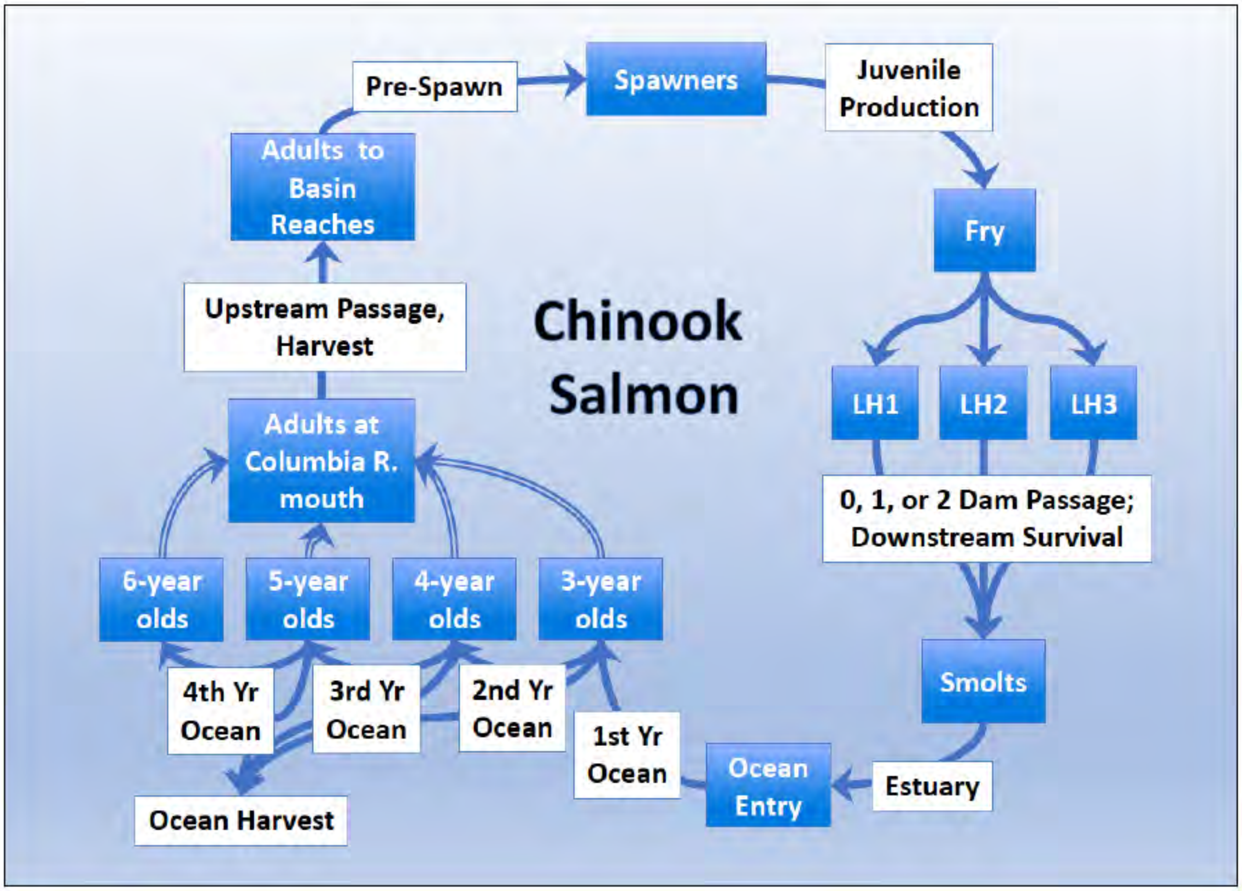



**Figure 3.8-15. Conceptual representation of the Life Cycle Model adapted from Myers et al. 2018.**

Output from the LCM is used to compute VSP metrics. Productivity is defined as the recruits (juveniles that successfully transition to the standing population) per spawner (the parent stock) averaged over a timeline of interest (Note that this approach is different from that of the Integrated Passage Assessment that measures the maximum productivity of a population). Abundance is expressed as equilibrium abundance, or the abundance at which the population is considered stable, evaluated over a number of years. These metrics inform the quasi-extinction risk (QET), or the probability of the population declining below an identified threshold abundance in 100 years or less. The threshold abundance is defined relative to historic population size (Zabel et al. 2014, COPII App C). (Note that the timeline used for this projection into the future differs from that of the Integrated Passage Assessment). Spatial structure and diversity are more difficult to quantify and are generally given less weight in the VSP calculation (ref). Juvenile emigration, and adult upstream migration is calibrated using empirical data where they exist, and informed assumptions where data are limited. The adult ocean phase is informed using observed and monitored correlates (ie, conditions in the ocean that correspond to salmon success) (ref). The aim of the Life Cycle model is to describe viability with respect to historic conditions and current management actions.

There are several key assumptions that must be made using this approach:

1. The model considers above and below dam populations, i.e., it includes both populations directly and indirectly impacted by the dam.
2. The model projects beyond the management action (100 years into the future).
3. The model assumes productivity is based on the long-term average of the projection over 100 years.
4. Spawner-to-fry production is dependent of the number of other individuals in the system, and follows a Beverton-Holt relationship.
5. Juvenile freshwater rearing success is independent from the number of juveniles in the system, i.e., there is no competition for resources
6. The No Action Alternative is reflected of actual conditions
7. Fish are subject to variable ocean survival.
8. Effects of temperatures due to actions are assumed from USGS modeling of three water years: 2011, 2015, 2016; The differences between years are applied to reaches below dams according to FBW-characterized water years (Abundant (2011), Adequate (2016), insufficient (2015), deficit (2015)).
9. Other than effects directly related to the No Action Alternative and Action Alternatives, there is an assumption of stationarity for parameters related to FW habitat, ocean conditions (and variability), and climate.
10. Assuming stationarity in proportions of juvenile outmigrant trajectories going to the ocean.

#### *3.8.2.1.4 Bull Trout Assessment Model*

To assess the effects of the WVS EIS alternatives on bull trout, a habitat assessment framework was developed following the principles and approaches applied by Schaller et al. (2014), with additional considerations of reservoir and fish passage conditions at large dams, and limiting factors documented in the Oregon Bull Trout Recovery Strategy (USFWS and others 2015).

Schaller et al. (2014) surveyed biologists with knowledge of bull trout to identify and weight variables affecting aquatic habitat conditions for bull trout. Scores were defined for assessing each of the variables for different life stage needs of bull trout, and then applied with the weighting factors to assess habitat conditions in river reaches of interest.

The highest weighted variables identified by Schaller et al. (2014) were surface flow, water temperature and passage impediments (see Table 3.17 in Schaller et al. 2014), indicating these were considered the most important variables by the biologists surveyed. Other viable weightings were much smaller, indicating they would have much less of an influence when comparing effects among alternatives in an assessment. We therefore focused the habitat assessment for the WVS EIS on surface flow, water temperature and passage conditions.

For purposes of the WVS EIS bull trout assessment, habitat reaches were defined consistent with those recently applied by ICF (2022) when modeling habitat conditions using the Ecosystem Diagnostic and Treatment (EDT) model. This allowed for the application of information on habitat conditions for variables of interest already summarized by ICF to be used.

We assumed all bull trout would utilize reservoirs that are located downstream of each impounded river reach being assessed. This is based on Zymonas et al. (2021) reporting that most bull trout populations in the Willamette Basin are adfluvial (spawn in streams; rear and forage in lakes or reservoirs).

Additional variables not explicitly considered by Schaller et al. (2014) which are important when assessing reservoir use by bull trout are predation and fisheries. Barrows et al. (2016) assessed available information on habitat changes from large dams on the Columbia mainstem and concluded it is unknown whether or not changes in the river system with the addition of reservoirs are beneficial for bull trout growth and survival. Both predation and harvest are included as primary threats to recovery of bull trout in the Upper Willamette. Reservoirs of the WVS include piscivorous fishes known to prey on salmonids, including pike minnow, walleye and smallmouth bass. Predation risk was scored based on the piscivorous fish species present in each reservoir. Local sport fisheries increase the risk of stress, injury, and mortality. Evidence of injury from hook and line capture of bull trout has been reported for bull trout in Hills Creek and South Fork McKenzie (ODFW 2021; Zymonas et al. 2021). Since USACE does not have any authority to change sport fishing regulations, we assumed current fisheries regulations and level of fishing effort (pressure) would continue under each WVS EIS alternatives. Predation risk and fisheries variable scores were used to decrement the value of the habitat scores.

We did not explicitly incorporate risks from catastrophic events (e.g. wildfires or landslides) into the assessment of bull trout since these events would in most cases result in negative effects for bull trout populations in the Willamette regardless of fish passage conditions. Bull trout are dependent on high elevation streams. If bull trout move downstream of WVS dams to rear and a catastrophic event occurs affecting habitat and/or survival of bull trout below the dam, we assume this scenario would be a negative impact on population performance with loss of potential spawners from the population. If bull trout move downstream of WVS dams to rear and a catastrophic event occurs above the dam, we also assume this scenario would be a negative impact on population performance with loss or degradation of habitat and/or survival of bull trout occupying habitat above the dam. Only in the case where a catastrophic event occurs effecting habitat conditions below a WVS dam, but most/all of the population does not have access to habitat below the dams, we would assume would result in limited impact to bull trout population performance in addition to reduced exposure to downstream limiting factors.

Compared to Schaller et al. 2014 we modified how passage impediments were considered in order to better account for conditions found at WVS dams currently and under each WVS EIS alternative. We characterized passage at dams for bull trout as either not available, partially available or fully available. Under the no passage available category, we assumed poor downstream passage conditions and no upstream passage are provided. For passage to be fully available, we assumed both effective up and downstream passage is present. Other conditions were assumed to fall in the partially available passage category. For the WVS EIS, operational downstream passage with upstream passage would be in this category. Passage condition categories were scored and used as an adjustment factor for scoring habitat conditions available below WVS dams where bull trout currently reside upstream (Cougar Dam and Hills Creek) or where they are being considered for reintroduction (Detroit Dam). This qualitative approach does not account for uncertainty in the effectiveness of different passage conditions for bull trout. Considering that passage facilities being considered among the WVS EIS alternatives are designed for anadromous salmonids, it is unknown whether these facilities are entirely suitable for migratory bull trout. As assumed for Columbia River mainstem dams (Barrows et al. 2016), they may delay or possibly discourage bull trout from freely moving throughout critical habitat in the mainstem, and they may also impede bull trout dispersal between subbasins.

Three bull trout populations were included in the bull trout assessment: populations that currently exist in headwater tributaries above Cougar and Hills Creek dams, and an assumed reintroduced bull trout population above Detroit Dam. We included a population above Detroit Dam since USFWS also plans to reintroduce bull trout above Detroit Dam (Hudson 2017). We assumed bull trout had been reintroduced above Detroit Dam, given the 30-year time horizon of the EIS effects analysis.

**Bull trout habitat score** = [above principal dam hydrology score + temperature score * reach length * predation risk factor * fisheries risk factor] + [below principal dam hydrology score + temperature score * reach length * predation risk factor * fisheries risk factor * passage condition factor]

<u>**Exposure to Limiting Factors and Risks Under Different Dam Passage Conditions**</u>

In order for access to additional habitat to be beneficial it must lead to increases in abundance, productivity (adult recruitment), and diversity. Expanded distribution could also reduce risks from catastrophic events (e.g., large wildfires or landslides), if spawning can still occur, and the expansion in distribution does not reduce productivity or spawner abundance over time for the primary population.

Bull trout collected at the Cougar adult fish facility demonstrates that some individuals will move downstream of the dam then return upstream to the base of the dam where they are effectively collected and moved back upstream (e.g., Zymonas et al. 2021). Most of those returning are mature adults, based on their size. However, data are lacking on the growth and survival for bull trout that move below WVS dams and it is not possible to determine if the rate of mortality for individuals moving below principal dams is greater than the rate of return and spawning in the principal population. Benefits of providing passage and access to habitat below WVS dams could include access to additional rearing/foraging habitat or spawning habitat, access to other spawning populations, increase in distribution reducing risks from catastrophic events (e.g., wildfires, large landslides). However, there are also many risks for bull trout that move downstream which act to diminish the potential benefits of accessing additional habitat below dams. These include injury or mortality from passage at large dams or diversion dams, the inability to move back upstream of dams lacking effective passage facilities, delay in passage where facilities exist, exposure to poor habitat conditions (e.g., higher water temperatures), injury or mortality from predators or angling. We also did not find any evidence of satellite populations having resulted from bull trout volitionally moving below principal dams, however this may be due to limited data availability.

The Oregon Bull Trout Recovery Strategy prepared by USFWS and others lists the following statewide limiting factors (Table 3.8-11), and those specifically identified for bull trout in the Upper Willamette. Exposure to all of these known limiting factors would be expected to increase with access below dams for bull trout below Cougar, Hills Creek and Detroit/Big Cliff dams.

**Table 3.8-11. Limiting factors identified in the Oregon Bull Trout Recovery Strategy**

| Statewide Limiting Factors | Upper Willamette Limiting Factors |
|---|---|
| Temperature | Altered flow and geomorphic processes |
| Flow | Entrainment and fish passage |
| Barriers | Illegal harvest |
| Human development | Prey base |
| | Hybridization and competition |
| | Predation |

Source:S. Gunkel, personal communication, 06 OCT 2021. Slide presentation to USACE on the Oregon Bull Trout Recovery Strategy

To assess the value of improving access to habitat downstream of primary dams, effects on population abundance, productivity, diversity and distribution should be considered. It is not known if the current downstream emigration rate for bull trout below dams is equal to or greater than their return rate at Cougar and Hills Creek dams. In the Deschutes River, where cool water temperatures are maintained by significant ground water inputs, return rates of bull trout passing downstream of Round Butte Dam have been high (unpublished data emailed from Chris Allen and Peter Lickwar, USFWS to Rich Piaskowski, USACE, 2.17.22). However, higher water temperatures and multiple other limiting factors exist below WVS dams, as referenced above from the Oregon Bull Trout Recovery Strategy. If emigration rates leads to a decline in the number of spawning bull trout over time, then the existing populations will decline unless satellite spawning areas are established downstream.

There is not any evidence that spawning below WVS dams is occurring, nor locations where spawning below WVS dams could potentially occur. Zymonas et al. (2021) assessed conditions in the North Santiam and Middle Fork Willamette Sub-basins. They referred to "McKenzie Basin reference" water temperature criteria for reintroduction assessments in the Willamette Basin that would include spawning and early juvenile rearing habitat having summer temperatures < 8°C and incubation temperatures averaging < 5°C, although numeric criteria may be flexible and influenced by other abiotic and biotic factors. Among locations water temperatures were monitored in the Middle Fork Sub-basin, Fisher Creek may provide the most suitable site for spawning and early rearing in the portion of the NFMF watershed accessible to migratory fish. Fisher Creek did not meet the McKenzie Basin reference criteria however. Due to the marginal temperature conditions observed, Zymonas et al. (2021) recommended "a preliminary experimental approach to assess survival of Upper Willamette Bull Trout in a warmer thermal regime". Skookum Creek was the only other stream reach noted by Zymonas et al. (2021) in the accessible portion of the NFMF watershed that provided colder temperatures and greater discharge, but this was an extremely short reach of potential spawning habitat (~50 m) between extreme high gradient cascades and dispersal into a large wetland populated by Brook Trout. Given the uncertainty that spawning could occur below Hills Creek Dam, it may be most prudent to first attempt to establish spawning below Hills Creek Dam before providing passage. If successful spawning is demonstrated below Hills Creek, it would reduce risks from a population sink occurring from increased rates of downstream fish passage, as well as risks from catastrophic events above Hills Creek Dam. If, however, establishing spawning below Hills Creek Dam is not successful, it would be important to assess recruitment rates back upstream from individuals passing downstream of the dam before providing long-term passage downstream, especially when considering climate change will further increase water temperatures and reduce summer base flows at rates greater at lower elevations.

In the North Santiam Sub-basin, Zymonas et al. (2021) documented suitable spawning and rearing areas upstream from Detroit Reservoir, but did not survey stream reaches below Detroit and Big Cliff dams. For purposes of assessing potential spawning and early rearing potential in stream reaches in the North Santiam Sub-basin below these dams, we considered water temperature data from USGS monitoring sites and elevation. Streams meeting the McKenzie Basin reference water temperature criteria were not apparent in the USGS temperate gauge data reviewed. It would therefore be important to assess recruitment rates back upstream from individuals passing downstream of Detroit Dam before providing long-term passage downstream of bull trout downstream once they are re-established above Detroit Dam, especially when considering climate change will further increase water temperatures and reduce summer base flows at rates greater at lower elevations.

We also considered that areas below dams are predicted to significantly degrade with respect to habitat suitability for bull trout due to climate change and land use impacts, and in some cases become definitively unsuitable (e.g., Wenger et al. 2013). Habitat quality below dams is assumed to further degrade over the 30-year time period of the WVS EIS, due to predicted climate change effects on precipitation and air temperatures, leading to changes in hydrology, water temperatures, fire, competition with warmwater and exotic fishes, changing land use and increasing development, among other factors.

Lacking emigration and upstream return rates of bull trout at WVS dams, we assume that risks of mortality is high for emigrants passing below dams due to the numerous limiting factors present, the prediction of further habitat degradation, and that there would not be spawning below dams. Since existing bull trout populations above Cougar and Hills Creek dams, which are currently stable or increasing, rely on reservoirs for rearing and foraging, we also considered the extent that reservoir conditions would change in each alternative. A fish passage measure which results in a reservoir pool which is largely drained would be expected to significantly affect rearing and forage opportunity. Passage measures which maintain a reservoir year-round were assumed not to significantly affect rearing and forage opportunity.

Structural downstream passage solutions could provide managers flexibility given uncertainty in the value of dispersal of bull trout below WVS dams. Structural passage would allow collected individuals to be marked, and then either passed downstream or returned to WVS reservoirs above dams. Monitoring would allow determination if the recruitment rate back into the spawning population above a WVS dam is equal to or less than the rate of individuals passing downstream and used to guide ongoing management. However, additional investigation could also inform the effects and risks of providing passage downstream passage prior to investing in passage for bull trout. Available technology allows for marking and recapture studies to estimate emigration and return rates without the need to physically recapture fish once marked.

Based on the above, we categorized risks for bull trout populations residing above Detroit and Hills Creek dams as high for those providing increased access to habitat below dams (improved passage at dams). For Cougar, due to the maintenance of cooler water below Cougar Dam and the Upper McKenzie watershed, we scored the risk level for WVS EIS alternatives with improved dam passage as moderate if the reservoir is maintained, and high if the reservoir is significantly reduced.

For alternatives where fish passage is not changed from existing conditions, we categorized the risks as low. This is primarily based on available information showing existing populations of bull trout above Cougar and Hills Creek as stable or increasing, and the assumption that habitat conditions will degrade and known limiting factors will be exacerbated below dams with climate change.

##### *3.8.2.1.5 Supporting Model 1: Fish Benefits Workbook*

The Fish Benefits Workbook is used to inform downstream passage for all three population models. It characterizes fish passage conditions given dam operations and fish behavior. It was created as a tool for the Configuration and Operation Plan (COP). While information to populate The Life Cycle model was available for upstream passage and downstream effects on spawning and rearing, downstream passage success under the alternative actions remained uncertain, particularly for structures that had not yet been designed or successfully implemented in other basins. Passage at Willamette high head dams is complicated due to fluctuations in pool elevation to mitigate flood risk during winter storms. Downstream passage alternatives needed to include consideration of pool elevation changes, juvenile attraction to flow, and the ability to find and survive passage outlets.

In response, the Corps created the Fish Benefits Workbook: a spreadsheet application that uses the hydrological period of record, flow information, available water, and importantly, the ability of a fish to find and use a passage route. These flow-passage relationships are described in Appendix K of the COP (USACE 2015). The relationships rely primarily on the concepts of "fish bearing flow" and the effectiveness at a given dam outlet. To inform the Fish Benefits Workbook passage rates, the Corps proposed completion of a synthesis of downstream passage data across several species in the region to inform performance of alternative structures (COP 2015). The model only encompasses what is occurring from the forebay of a dam to the tailrace. It does not include information about reservoir survival or what happens after survival to the tailrace. The output from Fish Benefit workbook is downstream passage survival, given the ability of a fish to use and survive a route/outlet. Downstream passage survival is passed to the NOAA LCM, the IPA, and EDT population models. Each of these models uses downstream passage survival to simulate the number of survivors to the next reach.

There are a number of key assumptions in the Fish Benefit Workbook:

Fish are available to pass if they are in the forebay of a dam.

There are generally three types of fish that will pass: fry that leave in their first spring, sub-yearlings that leave in the fall, and yearlings that leave in their second spring. These types are not constrained. For example, fry may leave in other months of the year up to becoming a sub-yearling.

The yearling stage begins January 1.

Fish timing to the arrival at a dam comes from Alden et al. (2014) with adjustment given the new availability of a passage route. For example, it is assumed that the arrival timing may change if juveniles are provided a year-round route as opposed to a seasonal route.

Dam passage efficiency, or the proportion of fish from the forebay of a dam that pass, was based on available data where it existed. Dam passage efficiency for novel fish passage structures was calculated using the methodology of Kock et al. (2019).

Fish passage structure designs were based on existing design information previously developed for Cougar and Detroit.

Where fish must pass a high head dam followed by a reregulation dam (for example, Detroit and Big Cliff), the mortality between the two dams is assumed to be between 15%-20%.

For a complete list of assumptions by project, refer to the FBW parameter documentation supporting information included in Appendix E.

#### *3.8.2.1.6 Supporting Model 2: Flow-Survival Relationships*

Juvenile and adult fish survival below the dam is affected by downstream factors including TDG, flow, and the availability of habitat. Often, water management decisions involve tradeoffs among multiple objectives or legal authorities. The US Geological Survey, Oregon Cooperative Fish and Wildlife Research Unit, Department of Fish and Wildlife, and Oregon State University have developed a series of decision support sub-models for UWR spring Chinook and winter steelhead to characterize water management tradeoffs and effects on key habitat features (Peterson et al. 2022). The decision sub-models, dependent on a given hydrology and water temperature regime, predict four different life history outcomes: 1) the number of Chinook reaching emergence and surviving to swim-up, 2) the number of Chinook adult equivalents, 3) the number of outmigrating winter steelhead, and 4) the survival rate of age-1 juvenile steelhead. Model predictions were driven by a number of life history and habitat inputs such as temperature, habitat-discharge relationships, and territory size.

Descriptions and assumptions of the four sub-models can be found in Peterson et al. (2022). All models operated on a weekly time step that began in the eighth week of the year and ran through April of the following year. Models are only assessing below dam spawning and juvenile rearing. Hydrology inputs were based on ResSim model results provided by the Corps for the NAA and action alternatives. Water temperature inputs were based on CE-QUAL-W2 model results provided by the Corps for the NAA and action alternatives. The sub-models produced predictions for each sub-basin, for the NAA and each EIS action alternative, in each year of three representative water years in which water temperatures and hydrology inputs were applied (2011, 2015 and 2016). Sub-model predictions (using median habitat criteria results provided by Peterson) for each action alternative were compared to the No Action Alternative (BiOp flows). Due to the multiple survival models, and differences in output units from each model, survival results were ranked for each model, using the RANK.EQ function in Excel, to prepare a comparison of results for the two species and across alternatives.

The results of this Draft PEIS are presented by sub-basin and across alternatives. Performance metrics are presented for the NOAA LCM and the IPA. The overall basin performance under each alternative is demonstrated by the EDT output. The LCM and IPA produce similar performance metrics that are dependent on the projected performance over a given timeline in the future:

**Table 3.8-12. Summary of performance metrics for each sub-basin population model**

| Performance Metric | LCM | IPA |
|---|---|---|
| Future timeline | 100 years | 30 years |
| Spawner abundance | Mean geomean of adult spawners over 100 years | Median geomean of adult spawners from year 16-30 in the projection |
| Mean recruits per spawner (R/S) | Mean recruits per spawner over 100 years | Median recruits per spawner from years 1-5 (maximum productivity) |

| Performance Metric | LCM | IPA |
|---|---|---|
| Mean quasi-extinction risk (QET) | The probability of population extinction over 100 years | The probability of population extinction over 30 years |

There are a few key differences in how both models output the performance metrics, mainly the timeline under consideration. First, the LCM predicts 100 years in the future while the IPA predicts 30 years into the future. This difference arises from differences in how the outputs are used for Willamette System project management (IPA) versus purposes explicitly for salmon conservation (LCM). The LCM requires 100 years to compute VSP. Conversely, the IPA only considers the probable timeline of the proposed management action (30 years). This is because the selected management action is likely to change as the system changes in the future.

The second major difference arises from the point in the future where recruits per spawner is measured. In the LCM, recruits per spawner is averaged over the entire 100 years. Therefore, the value should remain close to 1.0 if the population is stable under a given alternative. The IPA produces the median recruits per spawner in years 1-5 of the projection. This time period represents when the population is most likely to respond to a management action and represents the maximum productivity of a population under a given alternative. Recruits per spawner values in the IPA should be substantially greater than 1.0 if the population is viable under a given alternative.

Lastly, while the LCM predicts future abundance of above and below dam populations, the IPA only tracks the above-dam populations.

EDT does not produce a projection into the future. Instead, it uses current or expected habitat features to predict salmon success or failure under a given alternative. It is a simulation based on the expected habitat condition under each alternative. EDT produces performance metrics for each alternative and three representative year types: 2011 (wet), 2015 (dry), and 2016 (normal).

The total Alternative effects are given at the end of the results description.

**Table 3.8-13. EDT performance metrics at the sub-basin level**

| Performance metric (PM) | EDT |
|---|---|
| Diversity | The percentage of life history strategies that are successful under a given alternative |
| Productivity | The expected recruits per spawner basin-wide under a given alternative |
| Equilibrium Abundance | The population size once the population has stopped increasing or decreasing |

### *3.8.2.2 Environmental Consequences Summary*

The NAA would represent the current management direction of the WVS. Specific measures included in the NAA are described in Section 2.4.1. The NAA is predicted to have MAJOR adverse impacts on UWR Chinook salmon and winter steelhead. Life cycle models predict high extinction risk in all sub-basins for both species. Adverse impacts on bull trout are predicted to be MINOR. Bull trout above Cougar have been stable for several years and have been increasing above Hills Creek. Habitat scores for bull trout are reasonable, with one hundred percent of the spawning habitat available, and 70% of the rearing/foraging habitat available. The WVS passage conditions at dams limit bull trout access to below dam rearing/foraging habitat. Climate change is predicted to further degrade habitat for bull trout particularly below dams and will reduce the ability to meet operational fish passage, minimum flows, and water temperature objectives below dams for Chinook and steelhead.

Alternative 1 is the storage focused alternative. Specific measures included in the Alternative 1 are described in Section 2.4.3. Large floating fish passage structures would be implemented compatible with water storage needs in the North, South Santiam, and the Middle Fork. A fall deep drawdown at Fall Creek will continue. Minimum below-dam flow values support capturing water in reservoirs during spring. Alternative 1 implementation is predicted to have MAJOR impacts on Chinook salmon and MINOR adverse impacts on winter steelhead in the North and South Santiam. Lifecycle models predict low extinction risk for Chinook in the North and South Santiam, and high risk of extinction in the McKenzie and Middle Fork. The downstream passage structure at Lookout Point is dependent on the dam operations and predicted to perform poorly likely due to the storage theme of Alternative 1. Both life cycle models predict low extinction risk in Santiam winter steelhead populations, although one model predicted low recruits per spawning for the South Santiam. The EDT output indicates that Alternative 1 is somewhat resilient to different hydrology year types with respect to life history diversity. Scores and risks for bull trout would be ranked similar to the No Action Alternative, with MINOR effects predicted. Habitat scoring for bull trout is only marginally better than in the No Action Alternative with rearing/forage habitat increases for North Santiam bull trout below Detroit. Structural improvements for fish passage and water temperature provide resilience to climate change by increasing operational flexibility in the North Santiam, South Santiam, McKenzie and Middle Fork sub-basins.

Alternative 2A has an integrated management strategy theme. Specific measures included in the Alternative 2A are described in Section 2.4.4. This alternative includes structural downstream passage at Detroit, Foster, Cougar and Lookout Point dams, and operational passage at Green Peter Dam. A fall deep reservoir drawdown at Fall Creek Dam will continue. Alternative 2A would have MODERATE adverse effects on Chinook salmon, predicted to produce the most viable populations compared to other alternatives and retains the McKenzie core legacy population. For Chinook and steelhead, there was agreement in most cases found from assessing population performance with lifecycle models. One exception was for the South Santiam. The IPA predicts low extinction risk in the South Santiam with a viable population above Foster, whereas the LCM does not. Alternative 2A produces the most optimistic outcomes for Chinook salmon in the Middle Fork among the alternatives, accomplished with a downstream passage structure at Lookout Point exclusive of passage at Hills Creek. Alternative 2A would have MINOR adverse impacts to Santiam winter steelhead populations, with good performance in all metric dimensions in both life cycle models except for the South Santiam under the LCM. EDT results shows resiliency with respect to recruits per spawner. Bull trout habitat scores and risks are comparable to Alternative 1, with a fish passage addition providing access to habitat below Cougar Dam. Alternative 2A would have MINOR adverse impacts for bull trout. Structural improvements for fish passage and water temperature provide resilience to climate change by increasing operational flexibility in the North Santiam, South Santiam, and Middle Fork sub-basins.

Alternative 2B also has an integrated management strategy theme. Specific measures included in the Alternative 2B are described in Section 2.4.5. The only difference with Alternative 2A is that 2B has an operational downstream fish passage measure at Cougar Dam (deep drawdown to near the diversion tunnel in spring and fall) instead of a structural measure. Cougar Reservoir would largely be drained in spring and only partially refilled in summer due to summer inflow, resulting in most juvenile Chinook moving downstream of Cougar Dam and a significant reduction in rearing/foraging opportunity within the reservoir for bull trout. Many bull trout would be expected to move upstream into the South Fork McKenzie, or below Cougar Dam during spring and fall reservoir drawdowns. Suitable habitat for bull trout exists above and below Cougar Dam and Reservoir, however carry capacity and other effects of redistribution on survival and spawning is uncertain. The deep draft in spring will also eliminate conservation water storage, resulting in lower summer stream flows and changes in water temperatures below Cougar Dam. These differences will affect fish rearing/foraging patterns both above and below Cougar Dam. Compared to Alternative 2A, 2B results in increased adverse impacts to Chinook (moderate) and bull trout (moderate) in the McKenzie, otherwise impacts are predicted to be the same as for Alternative 2A. Structural improvements for fish passage and water temperature provide resilience to climate change by increasing operational flexibility in the North Santiam, South Santiam, and Middle Fork sub-basins.

Alternative 3A has an operational theme (i.e., fish passage, water quality and other missions are accomplished by operation of existing structures). Specific measures included in the Alternative 3A are described in Section 2.4.6. Reservoir drawdowns will occur in spring and fall at Detroit, Cougar (to RO), and Lookout dams. Spring surface spill and fall deep drawdowns will occur at Green Peter and Hills Creek. A fall deep drawdown at Fall Creek will continue. Alternative 3A would have Major adverse impacts for Chinook and steelhead. Predicted performance for these species is very similar to the NAA, with some improvement in North Santiam Chinook and South Santiam steelhead. Alternative 3A would have Major adverse impacts for Bull trout. Reservoir rearing/foraging area is significantly reduced in both Detroit and Cougar reservoirs and expected to result in increased movement into more degraded rearing/foraging habitat below Detroit and Hills Creek dams where spawning habitat does not exist and human disturbance is high. Climate change is predicted to further degrade habitat for bull trout below dams and will reduce the ability to meet operational fish passage, minimum flows, and water temperature targets below dams for Chinook and steelhead.

Alternative 3B also has an operational theme, with a different combination of fish passage measures. Specific measures included in the Alternative 3B are described in Section 2.4.7. Reservoir drawdowns will occur in spring and fall at Green Peter (to RO), Cougar (to DT), and Hills Creek dams (to RO). Spring surface spill and fall drawdowns (to RO) will occur at Detroit and Lookout Point dams. A fall deep drawdown at Fall Creek will continue. Alternative 3B would have Moderate to Major adverse impacts for Chinook and steelhead. Performance for Chinook in the North Santiam and McKenzie is predicted as viable to nearly viable, and the same for steelhead in the North and South Santiam. Alternative 3B would have Moderate to Major adverse impacts for bull trout. Reservoir rearing/foraging area is reduced in Cougar Reservoir, and passage will result in increased movement into more degraded rearing/foraging habitat below Detroit and Hills Creek dams where spawning habitat does not exist and human disturbance is high. Climate change is predicted to further degrade habitat for bull trout below dams and will reduce the ability to meet operational fish passage, minimum flows, and water temperature targets below dams for Chinook and steelhead.

Alternative 4 is a structural focused alternative and includes large floating fish passage structures coupled to temperature structures in the North, McKenzie, and the Middle Fork. Smaller structures are included at Foster Dam in the South Santiam. A fall deep drawdown at Fall Creek will continue. Specific measures included in the Alternative 4 are described in Section 2.4.8. Alternative 4 adverse effects are predicted to be Moderate for Chinook salmon and MINOR for winter steelhead. Life cycle models predicts low extinction risk for Chinook for the North and South Santiam, and for the McKenzie. Only one model predicts low extinction risk for Middle Fork Chinook. Life cycle models predict low extinction risk for North Santiam winter steelhead, but only one model predicts low extinction risk for South Santiam steelhead. The EDT output also indicates Alternative 4 is somewhat resilient to different hydrology year types with respect to life history diversity. Alternative 4 is predicted to have Moderate adverse impacts for bull trout. Habitat scoring for bull trout is improved in all three sub-basins due to passage actions, however access to below dam habitat increases demographic risks especially below Hills Creek and secondarily below Detroit where spawning habitat does not exist, and human disturbance is high. Climate change is predicted to further degrade habitat for bull trout below dams. Structures for fish passage and temperatures will increase resiliency to climate change by improving operational flexibility.

Alternative 5 is the same as Alternative 2B but includes different minimum flows. Specific measures included in the Alternative 5 are described in Section 2.4.9. Despite the change in minimum flows, little to no difference between 2B and 5 is predicted regarding reservoir volumes or flows below dams, since reservoir drafting during the conservation use season and early flood seasons result in stream flows remaining above minimums. Therefore, the same impacts to Chinook, steelhead and bull trout are predicted from Alternative 5 as for Alternative 2B. Structural improvements for fish passage and water temperature provide resilience to climate change by increasing operational flexibility in the North Santiam, South Santiam, McKenzie and Middle Fork sub-basins.

### *3.8.2.3 No Action Alternative*

#### *3.8.2.3.1 North Santiam*

Under the No Action Alternative, no downstream passage is implemented for juvenile downstream passage at Detroit.

**Chinook Salmon**

The summarized performance metrics for Chinook under the NAA for the LCM and IPA models are described in Table 3.8-14. Under the No Action Alternative, no downstream passage is implemented for juvenile downstream passage at Detroit. This results in few juveniles surviving to emigrate from above Detroit Dam, and therefore too few natural origin adults returning from the ocean to maintain the population above Detroit Dam. The life cycle models are in agreement with respect to spawner abundance, but disagree with respect to recruits per spawner and quasi-extinction risk. This may arise from differences in assumptions about TDG under the No Action Alternative. EDT output indicates some robustness to water year type with respect to diversity but poorer performance for spawner abundance and Recruit per Spawner. Under the No Action Alternative, spring Chinook in the North Santiam would not demonstrate substantial population growth but may persist at very a very small population size. Based on the EDT, it is likely that annual water year variability would have observable effects on Chinook. Evaluation Criteria: The No Action Alternative under both life cycle models predicts unacceptable risks to viability in two of three performance metrics. Therefore, the NAA would have MAJOR adverse impacts on Chinook salmon in the North Santiam.

**Table 3.8-14. North Santiam NAA spring Chinook performance across each model**

| North Santiam | | | | |
|---|---|---|---|---|
| **Model** | **Spawner Abundance** | **Recruit per Spawner** | **Quasi-extinction Risk** | **Diversity** |
| LCM | Meets | Fails | Fails | NA |
| IPA | Meets | Meets | Meets | NA |
| EDT Wet | 1 | 3 | NA | 1 |
| EDT Dry | 3 | 1 | NA | 2 |
| EDT Normal | 2 | 2 | NA | 1 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Steelhead**

The summarized performance metrics for steelhead under the No Action Alternative for the LCM, IPA, and EDT are given in Table 3.8-15. Under the No Action Alternative, no downstream passage is implemented for juvenile downstream passage at Detroit. However, about half of the steelhead spawning habitat exists in the North Santiam Sub-basin below Detroit Dam, and therefore lifecycle models predict somewhat better performance in comparison to Chinook.

The LCM predicts viability in one of three categories while the IPA predicts non-viability in all categories. The EDT output suggests robustness across normal and wet years with respect to diversity but poorer performance in dry years. With respect to equilibrium abundance and productivity, EDT predicts better performance in normal and dry years and worse performance in wet years. Under the No Action Alternative, steelhead in the North Santiam may persist at low population sizes; however, the uncertainty about population performance indicates that steelhead could still be at high risk, particularly in variable water years. Evaluation Criteria: Given that both life cycle models predict non-viability in at least one of the performance metrics, the NAA is expected to have MAJOR adverse impacts on winter steelhead in the North Santiam.

**Table 3.8-15. North Santiam NAA winter steelhead performance across each model**

| North Santiam | | | | |
|---|---|---|---|---|
| **Model** | **Spawner Abundance** | **Recruit per Spawner** | **Quasi-extinction Risk** | **Diversity** |
| LCM | Meets | Fails | Fails | NA |
| IPA | Fails | Fails | Fails | NA |
| EDT Wet | 3 | 3 | NA | 1 |
| EDT Dry | 2 | 2 | NA | 2 |
| EDT Normal | 1 | 1 | NA | 1 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Bull Trout**

The summarized performance metrics for bull trout under the No Action Alternative are given in Table 3.8-16. Habitat scores are reasonable for the NAA with very limited passage under existing conditions. Although passage increases would provide access to habitat below dams, this passage increases demographic risks for each population currently residing above WVS dams by exposure to lower quality habitat and requires individuals to return and be trucked back above the dams to spawn and contribute to the population due to the lack of spawning habitat below dams. However, the facility at Minto may be used to collect adult bull trout to move them upstream of Detroit. Given available habitat and the possibility to use existing facilities to translocate adult bull trout upstream, effects on bull trout under the No Action Alternative in the North Santiam are predicted to be MINOR adverse.

**Table 3.8-16. Summary of bull trout habitat scoring and relative risk under the No Action Alternative in the North Santiam.**

| NAA | | | |
|---|---|---|---|
| **Sub-basin** | **Region** | **Score** | **Risk** |
| North Santiam | Above Detroit (rearing/foraging and spawning) | 41.52 | Low |
| | Below Detroit (rearing/foraging only) | 19.79 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

### *3.8.2.3.2 South Santiam*

Under the NAA, a continued spill operation would occur for downstream juvenile passage at Foster and there would be no downstream passage implemented at Green Peter. Upstream passage for adult fish would be provided by the existing adult fish facility at the base of Foster Dam. The combination of up and downstream passage allows Chinook and steelhead to access habitat above Foster Dam but not above Green Peter Dam.

**Chinook salmon**

The performance metrics for spring Chinook salmon in the South Santiam under the NAA are summarized in Table 3.8-17. In general, both life cycle models predicts that none of the performance metrics meet the minimum thresholds for viability. This likely in part due to the constraints on downstream fish passage survival by using existing water discharge routes at Foster Dam, given declining natural origin returns in recent years. The EDT outputs suggest that the No Action Alternative is sensitive to hydrology (i.e., year type) with dry years performing the worst in the South Santiam. This result likely reflects few days of spillway use in dry years resulting in poorer downstream fish passage survival. Under the No Action Alternative, spring Chinook are at high risk of extinction and negative population growth, likely due to the lack of effective passage, particularly in dry years. Evaluation Criteria: Given that the life cycle models predict non-viability in at least two of the three categories, it is predicted that the No Action Alternative would have MAJOR adverse impacts to spring Chinook in the South Santiam.

**Table 3.8-17. South Santiam NAA spring Chinook salmon performance across each model**

| South Santiam | | | | |
|---|---|---|---|---|
| **Model** | **Spawner Abundance** | **Recruit per Spawner** | **Quasi-extinction Risk** | **Diversity** |
| LCM | Fails | Fails | Fails | NA |
| IPA | Fails | Fails | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |

| South Santiam | | | | |
|---|---|---|---|---|
| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
| EDT Dry | 3 | 3 | NA | 3 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Steelhead**

The winter steelhead performance metrics under the NAA are summarized in Table 3.8-18. In general, both life cycle models indicate that very few of the performance metrics meet the minimum thresholds for viability. The EDT output suggests that the NAA is sensitive to hydrology with the exception of the Diversity metrics where wet and normal years perform comparably. Under the No Action Alternative, steelhead would be at high risk primarily due to the lack of adequate downstream passage and may demonstrate varied performance under different water year types. Evaluation Criteria: Given that both life cycle models predict non-viability in at least two of the three categories, it is predicted that the NAA would have MAJOR impacts on winter steelhead in the South Santiam.

**Table 3.8-18. South Santiam NAA winter steelhead performance across each model**

| South Santiam | | | | |
|---|---|---|---|---|
| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
| LCM | Meets | Fails | Fails | NA |
| IPA | Fails | Fails | Fails | NA |
| EDT Wet | 3 | 3 | NA | 1 |
| EDT Dry | 2 | 2 | NA | 2 |
| EDT Normal | 1 | 1 | NA | 1 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

#### *3.8.2.3.3 McKenzie*

Under the NAA, no downstream passage would be implemented at Cougar Dam. Adult Chinook (primarily hatchery origin) and bull trout collected at the Cougar adult fish facility at the base of the dam and trucked upstream of the dam to spawn. Downstream fish passage would occur through the regulating outlet or turbine penstocks with the reservoir pool operated between the minimum and maximum conservation pool elevations. In this case fish many fish will exit when water depths to the dam outlets is high, increasing risk of injury and mortality. Survival through these routes as operated has been shown inadequate for re-establishing a Chinook population above Cougar Dam.

**Chinook Salmon**

The spring Chinook performance metrics in the McKenzie under the NAA are given in Table 3.8-19. In general, both models indicate that the performance metrics do not meet the minimum thresholds for viability, in general, but differ in the mechanism. The LCM predicts adequate spawner abundance; however, the LCM accounts for up and downstream populations whereas the IPA only accounts for upstream populations. Since wild populations exist below Cougar, they contribute to overall spawner abundance, even though productivity overall is predicted to be low. The EDT output indicate that the NAA is sensitive to hydrology except with respect to Diversity where all water year types performed similarly, i.e., the NAA in the McKenzie is resilient to water year type with respect to life history diversity. Under the No Action Alternative, spring Chinook in the McKenzie are unlikely to persist at levels adequate to avoid demographic risk. While initial replacement rates may be above 1.0 in some cases, the population growth rate would not be high enough to sustain the population in the long term primarily due to the lack of effective downstream passage. Evaluation Criteria: Given that the life cycle models predicted non-viability in two of three categories, the NAA is predicted to have MAJOR adverse impacts on spring Chinook in the McKenzie.

**Table 3.8-19. McKenzie NAA spring Chinook salmon performance across each model**

| McKenzie | | | | |
|---|---|---|---|---|
| **Model** | **Spawner Abundance** | **Recruit per Spawner** | **Quasi-extinction Risk** | **Diversity** |
| LCM | Meets | Fails | Fails | NA |
| IPA | Fails | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 3 | NA | 1 |
| EDT Normal | 2 | 2 | NA | 1 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Bull Trout**

Although habitat score for bull trout in the McKenzie under the NAA are below values for Detroit (Table 3.8-20), bull trout populations above Cougar have been stable for several years (Zymonas et al. 2021). This indicates that even with limited downstream fish passage conditions to below dam habitat, this population is sustainable under the NAA. For bull trout that do survive downstream passage, the existing adult fish facility at the base of the dam would be used to collected and transport those migrating upstream back above the dam to re-enter the spawning population. It is predicted that the NAA would have a NEGLIGIBLE adverse impact on the bull trout population above Cougar Dam.

**Table 3.8-20. Summary of bull trout habitat scoring and relative risk under the No Action Alternative in the McKenzie**

| McKenzie | | | |
|---|---|---|---|
| **Sub-basin** | **Region** | **Score** | **Risk** |
| McKenzie | Above Cougar (rearing/foraging and spawning) | 11.83 | Low |
| | Below Cougar (rearing/foraging only) | 7.13 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

### *3.8.2.3.4 Middle Fork*

Under the NAA, no downstream passage would be implemented at Lookout Point or Hills Creek dams. Adult hatchery Chinook in excess of hatchery brood stock needs collected at Dexter Adult Fish Facility are trucked upstream of Lookout Point and Hills Creek dams to spawn. Downstream passage at Hills Creek, Lookout, and Dexter Dam occurs through existing outlets where on average downstream fish passage survival is low under the NAA dam operational regime. The existing adult facility at Fall Creek Dam in combination with the operational downstream passage by way of a fall reservoir deep drawdown will support maintaining the re-established Chinook sub-population above Fall Creek Dam.

**Chinook Salmon**

The performance metrics for spring Chinook in the Middle Fork under the NAA are summarized in Table 3.8-21. The performance metrics in both models are not predicted to meet the minimum thresholds for viability. This is not unexpected given the high prespawn mortality risk, high pHOS below Dexter dam, and lack of effective passage under the NAA. The EDT output indicates poor resiliency of UWR spring Chinook under the NAA in the Middle Fork, with dry years demonstrating the lowest performance in all dimensions. Under the No Action Alternative, spring Chinook would remain at high risk without significant natural production. While model results indicate that natural origin populations could sustain at low abundance levels, productivity is predicted to remain low and below threshold levels for viability. The lack of effective downstream passage and adequate temperature control in the Middle Fork produces higher overall risk for spring Chinook. Evaluation Criteria: Given that the IPA predicts non-viability in all categories, the NAA is predicted to have MAJOR adverse impacts to spring Chinook salmon in the Middle Fork.

**Table 3.8-21. Middle Fork NAA spring Chinook salmon performance across each model**

| Middle Fork | | | | |
|---|---|---|---|---|
| **Model** | **Spawner Abundance** | **Recruit per Spawner** | **Quasi-extinction Risk** | **Diversity** |
| LCM | Meets | Fails | Fails | NA |

| Middle Fork | | | | |
|---|---|---|---|---|
| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
| IPA | Fails | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 3 | NA | 3 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Bull Trout**

The bull trout performance metrics under the NAA in the Middle Fork are summarized in Table 3.8-22. The habitat score above Hills Creek is low relative to the McKenzie and North Santiam, but high above Hills Creek relative to the below dam component. This is because the below dam component experiences higher temperatures than in other sub-basins. Even without passage, the population above Hills Creek has increased in recent years (Zymonas et al. 2021), which indicates that this population performs reasonably well under the NAA. It is expected that climate change will only worsen habitat conditions particularly downstream of Hills Creek and other dams, and the habitat score is not expected to increase with passage below Hills Creek. Bull trout that move downstream as not able to re-enter the spawning population above the dam, however given the population has been growing under operational conditions assumed for the NAA, the population performance would not be expected to change. Since most bull trout remain upstream of Hills Creek Dam, they are not exposed to risks associated with poorer habitat conditions, angling, passage at other dams and other human-related factors. The NAA is expected to have NEGLIGIBLE impacts on bull trout in the Middle Fork.

**Table 3.8-22. Summary of bull trout habitat scoring and relative risk under the No Action Alternative in the Middle Fork**

| Middle Fork | | | |
|---|---|---|---|
| Sub-basin | Region | Score | Risk |
| Middle Fork | Above Hills Creek (rearing/foraging and spawning) | 10.06 | Low |
| | Below Hills Creek (rearing/foraging only) | 0 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

### *3.8.2.4 Alternative 1*

#### *3.8.2.4.1 North Santiam*

Under Alternative 1, construction of structural downstream fish passage (#392) would be implemented at Detroit Dam. Upstream fish passage for Detroit and Big Cliff dams would be provided using the existing Minto Adult Fish Facility. The combination of structural passage provides effective access to upstream habitat for Chinook and steelhead, leading to increased abundance and productivity. Passage improvements would also support passage of a re-introduced bull trout population above Detroit Dam to access habitat below the dam and return back upstream to re-enter the spawning population, but there are a greater number of limiting factors downstream increasing potential for mortality for individuals that move downstream. Since there is not any spawning habitat available downstream of the dam, individuals must survival and migrate back upstream, be collected and trucked above Detroit Dam, in order to re-enter the spawning population.

**Chinook salmon**

The performance metrics for Chinook in the North Santiam under Alternative 1 are summarized in Table 3.8-23. In general, both life cycle models are closely aligned. Alternative 1 indicates good performance in all categories. In nearly all Action Alternatives, the North Santiam demonstrated the best performance in all models. The EDT shows Alternative 1 resiliency with respect to recruit per spawner but not for equilibrium abundance or life history diversity. This suggests that while the alternative performs well overall, it may perform worse in drier years. Under Alternative 1, spring Chinook in the North Santiam would experience lower risk than under the No Action Alternative, primarily due to effective downstream passage and adequate temperature control to manage prespawn mortality. However, the different assumptions about TDG induced mortality among the two life cycle models may result in performance slightly less than expected. Given the reasonable performance across life cycle models with the exception of quasi-extinction risk, and the level of resiliency across different year types, it is expected that Alternative 1 will have MINOR adverse impacts on spring Chinook salmon in the North Santiam.

**Table 3.8-23. North Santiam Alternative 1 spring Chinook salmon performance across each model**

| North Santiam | | | | |
|---|---|---|---|---|
| **Model** | **Spawner Abundance** | **Recruit per Spawner** | **Quasi-extinction Risk** | **Diversity** |
| LCM | Meets | Meets | Meets | NA |
| IPA | Meets | Meets | Meets | NA |
| EDT Wet | 1 | 2 | NA | 1 |
| EDT Dry | 3 | 1 | NA | 3 |
| EDT Normal | 2 | 1 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Steelhead**

The performance metrics for winter steelhead in the North Santiam are summarized in Table 3.8-24. Unlike the spring Chinook metrics, winter steelhead performance demonstrate general concurrence except with respect to quasi-extinction risk. In general, the LCM predicted a higher average abundance under Alternative 1, whereas abundance in the IPA was an order of magnitude smaller. While predicted productivity in both models met the minimum threshold for viability, the IPA predicted a lower overall productivity than the LCM. EDT shows resiliency across recruit per spawner. Under Alternative 1, steelhead would experience lower risk due to effective downstream passage and adequate temperature control. The migration timing when compared to Chinook may also limit effects of TDG. Given the high performance and resiliency in recruit per spawner, it is expected that Alternative 1 would have MINOR adverse impacts to winter steelhead in the North Santiam.

**Table 3.8-24. North Santiam Alternative 1 winter steelhead performance across each model**

| North Santiam | | | | |
|---|---|---|---|---|
| **Model** | **Spawner Abundance** | **Recruit per Spawner** | **Quasi-extinction Risk** | **Diversity** |
| LCM | Meets | Meets | Meets | NA |
| IPA | Meets | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Bull Trout**

The performance metrics for bull trout in the North Santiam under Alternative 1 are summarized in Table 3.8-25. In general, more habitat is available once bull trout pass downstream of Detroit as compared to the No Action Alternative but there are a greater number of limiting factors downstream. It is also expected that climate change would only exacerbate these factors. Therefore, while habitat could be increased under Alternative 1, so to would the impacts from limiting factors. It is expected that Alternative 1 would have MODERATE adverse impacts to bull trout reintroduced to the North Santiam.

**Table 3.8-25. Summary of bull trout habitat scoring and relative risk under Alternative 1 in the North Santiam**

| North Santiam | | | |
|---|---|---|---|
| **Sub-basin** | **Region** | **Score** | **Demographic Risk** |
| North Santiam | Above Detroit (rearing/foraging and spawning) | 41.32 | High |
| | Below Detroit (rearing/foraging only) | 38.08 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

### *3.8.2.4.2 South Santiam*

Under Alternative 1, construction of structural downstream fish passage (#392) occurs at Foster and Green Peter. Upstream migrating fish are collected at the existing Foster Adult Fish Collection Facility, and a new adult collection facility would be constructed and operated at the base of Green Peter Dam. The structural fish passage improvements allow Chinook and steelhead to access habitat above Foster and Green Peter dams, supporting increased abundance ad productivity compared to the NAA. However habitat available above these dams is limited and at lower elevation, influencing hydrology and water temperatures, when compared to that above WVS dams in other sub-basins where Chinook occur. These differences can affect fish survival and population performance.

**Chinook**

The performance metrics for spring Chinook in the South Santiam under Alternative 1 are summarized in Table 3.8-26. The IPA was consistently more optimistic for Chinook in the South Santiam under Alternative 1. This is likely related to each model's relative sensitivity to the downstream passage measure implemented under a given alternative. In general, the LCM is more sensitive to structural downstream passage and populations tend to perform better under the LCM than the IPA, when downstream passage facilities are assumed. Under Alternative 1, downstream passage at Green Peter is accomplished using a combination of seasonal operations. Downstream passage operations in the IPA are almost exclusively informed by the assumptions in Fish Benefits Workbook for a given passage alternative, whereas in the LCM, other factors may influence the effectiveness of operational passage when compared to structural passage (eg, reservoir mortality, or the fate of fish who do not passage the dam under a given operational passage scenario). In general, both models assume that if adult returns fall below a threshold in four consecutive years within the timeline, it is presumed extinct. It is possible that the population did not go extinct in the IPA because the model only considers the timeline of the management action (30 years) whereas the LCM considers a timeline beyond the management action (100 years). Otherwise, the IPA predicted high performance for Alternative 1 because it represents the most optimistic scenario for spring Chinook in the South Santiam. Alternative 1 included structural passage at both Foster and Green Peter dams, which was assumed to provide the best downstream passage survival. EDT suggests there could be differences in performance under a given hydrology year, but the magnitude of these differences may be smaller given the structural solutions proposed for downstream passage. Therefore, Alternative 1 is expected to have MINOR adverse impacts on spring Chinook salmon in the South Santiam despite the fact that the LCM predicts extinction, because it is assumed that the duration of the management action more closely aligns with the IPA assumption of 30 years.

**Table 3.8-26. South Santiam Alternative 1 spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Fails | Fails | NA |
| IPA | Meets | Meets | Meets | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 3 | NA | 3 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Steelhead**

The performance metrics for winter steelhead under Alternative 1 in the South Santiam are summarized in Table 3.8-27. Both life cycle models agree with respect to equilibrium spawner abundance and quasi-extinction risk but did not agree with respect to spawner abundance only. The LCM predicted no production in the South Santiam for any alternative (i.e., Recruit per spawner = 0). This is an unexpected result given that a population with a low extinction risk should demonstrate a productivity at least near 1.0 to consistently escape extinction. At the time of this writing, this result cannot be explained. Therefore, we relied primarily on the IPA for South Santiam winter steelhead. Again, structural downstream passage at both Foster and Green Peter is assumed to convey the highest possible benefit for outmigrating juveniles, therefore, the performance metrics reflect high viability scores. The EDT output also indicates that Alternative 1 is somewhat resilient to different hydrology year types with respect to life history diversity, but not for equilibrium abundance or productivity. Alternative 1 is expected to have MINOR adverse impacts on winter steelhead in the South Santiam.

**Table 3.8-27. South Santiam Alternative 1 winter steelhead performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Fails | Meets | NA |
| IPA | Meets | Meets | Fails | NA |
| EDT Wet | 3 | 3 | NA | 1 |
| EDT Dry | 2 | 2 | NA | 2 |
| EDT Normal | 1 | 1 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

#### *3.8.2.4.3 McKenzie*

Under Alternative 1, no passage would be implemented at Cougar Dam. Fish passing upstream can be safely collected and trucked upstream using the existing adult facility completed in 2015. Fish passing downstream must use either the regulating outlet or turbine penstocks. Survival through these routes as operated has been shown inadequate for re-establishing a Chinook population above Cougar Dam.

**Chinook**

The performance metrics for spring Chinook in the McKenzie under Alternative 1 are summarized in Table 3.8-28. Under Alternative 1, no passage would be implemented at Cougar Dam. The life cycle models are in agreement with respect to equilibrium spawner abundance. This is not unexpected. The McKenzie sub-basin has populations of natural origin spawners below Cougar and the LCM takes that production into account. It assumes these populations are allowed to persist. The IPA only considers above dam natural origin components but considers only the lifespan of the management action (30 years). The EDT output indicates resiliency in all hydrology year types with respect to diversity but not equilibrium spawner abundance or productivity. This is also expected given that the McKenzie produces a wide spectrum of life history types even under the No Action Alternative due to above and below dam components. Given the lack of viability across the performance metrics, it is expected that Alternative 1 would have MAJOR adverse impacts to spring Chinook in the McKenzie.

**Table 3.8-28. McKenzie Alternative 1 spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Fails | Fails | NA |
| IPA | Meets | Meets | Meets | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 3 | NA | 1 |
| EDT Normal | 2 | 2 | NA | 1 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Bull Trout**

The performance metrics for bull trout in the McKenzie under Alternative 1 are summarized in Table 3.8-29. Bull trout populations above Cougar have been stable for several years under the existing passage conditions at Cougar Dam (Zymonas et al. 2021). This indicates that the population is sustainable under Alternative 1. It is predicted that the NAA would have MINOR impacts on the bull trout population above Cougar.

**Table 3.8-29. Summary of bull trout habitat scoring and relative risk under Alternative 1 in the McKenzie**

| Sub-basin | Region | Score | Demographic Risk |
|---|---|---|---|
| McKenzie | Above Cougar (rearing/foraging and spawning) | 11.86 | Moderate |
| | Below Cougar (rearing/foraging only) | 7.14 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

### *3.8.2.4.4 Middle Fork*

Under Alternative 1, The existing adult facility at Fall Creek Dam in combination with the operational downstream passage by way of a fall reservoir deep drawdown will support maintaining the re-established Chinook sub-population above Fall Creek Dam. Construction of structural downstream fish passage (#392) would be implemented at Lookout Point and no passage would be implemented at Hills Creek. Adult Chinook would be collected at the base of Dexter Dam in the adult fish facility and trucked upstream of Lookout Point Reservoir. The structural fish passage improvements allow Chinook to access habitat above Lookout Point Dam, support increased abundance and productivity compared to the NAA. However, high pre-spawn mortality, poor reservoir survival, and low smolt to adult survival impact the ability to achieve a population at a low extinction risk. The bull trout population above Hills Creek Dam has been growing under existing passage conditions. Under Alternative 1, individuals that move downstream of Hills Creek Dam would not be able to re-enter the spawning population above the dam. However, given the population has been growing, the population performance would not be expected to change under this Alternative. Since most bull trout remain upstream of Hills Creek Dam, they are not exposed to risks associated with poorer habitat conditions, angling, passage at other dams and other human-related factors.

**Chinook**

The performance metrics for spring Chinook under Alternative 1 in the Middle Fork are summarized in Table 3.8-30. Under Alternative 1, structural passage would be implemented at Lookout Point and no passage would be implemented at Hills Creek. The LCM and IPA results are consistent in predicted performance in the Middle Fork. Due to passage at Lookout, Alternative 1 is likely to meet a lower population risk for Chinook than under the NAA, however, lack of adequate temperature control could contribute to ongoing prespawn mortality and low intrinsic productivity. The EDT results showed that Alternative 1 was not resilient to different hydrology year types probably due to the inability to substantially manipulate temperature in this low elevation sub-basin. It is expected that Alternative 1 would have MAJOR adverse impacts to spring Chinook in the Middle Fork.

**Table 3.8-30. Middle Fork Alternative 1 spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Meets | Fails | NA |
| IPA | Meets | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 3 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

<u>**Bull Trout**</u>

The performance metrics for bull trout in the Middle Fork under Alternative 1 are summarized in Table 3.8-31. Similar to the No Action Alternative, there is no passage at Hills Creek. However, the population above Hills Creek has been increasing in recent years without passage (Zymonas et al. 2021). The demographic risk to this population is low without implementation of passage at Hills Creek. Since most bull trout remain upstream of Hills Creek Dam, they are not exposed to risks associated with poorer habitat conditions, angling, passage at other dams and other human-related factors. Therefore, Alternative 1 would have NEGLIGIBLE adverse impact on bull trout in the Middle Fork.

**Table 3.8-31. Summary of bull trout habitat scoring and relative risk under Alternative 1 in the Middle Fork**

<table>
<tr><th>Sub-basin</th><th>Region</th><th>Score</th><th>Demographic Risk</th></tr>
<tr><td rowspan="2">Middle Fork</td><td>Above Hills Creek<br>(rearing/foraging and spawning)</td><td>10.03</td><td rowspan="2">Low</td></tr>
<tr><td>Below Hills Creek<br>(rearing/foraging only)</td><td>0</td></tr>
</table>

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

### *3.8.2.5 Alternative 2A*

#### *3.8.2.5.1 North Santiam*

Under Alternative 2A, construction of structural downstream fish passage (#392) would be implemented at Detroit Dam. For upstream passage, fish would be collected at the existing Minto adult fish facility and trucked upstream. The structural fish passage improvements allow Chinook and steelhead to access habitat above Detroit Dam, and support increased abundance and productivity compared to the NAA. Passage improvements would also support passage of a re-introduced bull trout population above Detroit Dam to access habitat below the dam and return back upstream to re-enter the spawning population, but there are a greater number of limiting factors downstream increasing potential for mortality for individuals that move downstream. Since there is not any spawning habitat available downstream of the dam, individuals must survival and migrate back upstream, be collected and trucked above Detroit Dam, in order to re-enter the spawning population.

**Chinook**

The performance metrics for spring Chinook salmon under Alternative 2A in the North Santiam are summarized in Table 3.8-32. Alternative 2A performs well in both life cycle models likely due to the implementation of structural downstream passage at Detroit. The EDT output does indicate some lack of resiliency over different hydrology year types but interestingly, recruits per spawner is highest in wet and dry years and lower in normal years. This may indicate small differences in performance or could be driven by a functional relationship in EDT. Overall, Alternative 2A presents lower risk to spring Chinook, due to effective downstream passage, improved downstream flow management which provided rearing and holding opportunities below dam, and adequate temperature control, which would likely reduce prespawn mortality. Alternative 2A would be expected to have MINOR adverse impacts on spring Chinook salmon in the North Santiam.

**Table 3.8-32. North Santiam Alternative 2A spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Meets | Meets | NA |
| IPA | Meets | Meets | Meets | NA |
| EDT Wet | 1 | 1 | NA | 2 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 3 | NA | 1 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Steelhead**

The performance metrics for winter steelhead in the North Santiam under Alternative 2A are summarized in Table 3.8-33. Similar to Chinook salmon, winter steelhead perform well in most performance metric dimensions in both life cycle models. Winter steelhead would likely be at lower risk due to effective downstream passage, increased rearing and holding opportunities downstream, and reduced prespawn mortality. The IPA predicts a much higher quasi-extinction risk than the LCM (above 35% higher risk). EDT shows resiliency with respect to recruits per spawner where Alternative 2A performs best under wet year times and comparably well under dry and normal year types. Alternative 2A would have MINOR adverse impacts to winter steelhead in the North Santiam.

**Table 3.8-33. North Santiam Alternative 2A winter steelhead performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Meets | Meets | NA |
| IPA | Meets | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Bull Trout**

The performance metrics for bull trout in the North Santiam are summarized in Table 3.8-34. Habitat scores are high above and below Detroit under 2A. However, Alternative 2A carries high demographic risks if bull trout are not able to migrate back upstream of the dam to contribute to the above Detroit population. It is expected that Alternative 2A would have MODERATE adverse impacts on bull trout in the North Santiam.

**Table 3.8-34. Summary of bull trout habitat scoring and relative risk under Alternative 2A in the North Santiam**

| Sub-basin | Region | Score | Demographic Risk |
|---|---|---|---|
| North Santiam | Above Detroit (rearing/foraging and spawning) | 42.47 | High |
| | Below Detroit (rearing/foraging only) | 39.07 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

#### *3.8.2.5.2 South Santiam*

Under Alternative 2A, construction of structural downstream fish passage (#392) would be implemented at Foster. At Green Peter Dam upstream of Foster, a deeper fall reservoir drawdowns for fish passage (#40) and spring spill would be implemented to provide downstream fish passage. An adult fish facility would also be constructed at the base of Green Peter Dam. These fish passage improvements allow Chinook and steelhead to access habitat above both Foster and Green Peter dams, supporting the potential for increased abundance and productivity compared to the NAA. Compared to above other WVS dams, the relatively lower elevation habitat above these dams may constrain productivity and survival.

**Chinook**

The performance metrics for spring Chinook salmon under Alternative 2A are summarized in Table 3.8-35. The life cycle models agree with respect to equilibrium spawner abundance but not with respect to recruits per spawner or quasi-extinction risk. Again, this could reflect the complexity of the two-dam system in South Santiam where downstream passage at Green Peter in Alternative 2A is accomplished by operations and downstream passage and at Foster is accomplished using a structural solution. Given rates previously observed at Foster using structures and operations (Liss et al. 2020, Deng et al. 2019), it is likely that even if a population cannot be established above Green Peter, that the population above Foster would be successful through structural passage options. Therefore, the IPA may be more representative of performance in the South Santiam under 2A. Similar as mentioned under previous alternatives, the LCM tends to predict poorer performance when operational downstream passage is implemented compared to structural downstream passage. The implementation of operational downstream passage at Green Peter likely results in a lower performance weighting in the LCM when compared to the IPA. The EDT output show variable resilience to water year type by performance metric. Interestingly, the normal year type performed worse with respect to spawner abundance than the dry year type. This may be driven by an underlying functional relationship in EDT. For example, channel widths were not assumed to change with water management type because there is no information on how widths would change by reach. This may result in normal and dry years performing similarly. With respect to recruits per spawner, EDT predicted that Alternative 2A performed similarly in normal and dry years but best in wet years. With respect to diversity, dry years performed the worst, normal slightly better, and wet years the best. It is predicted that Alternative 2A would have MINOR adverse impacts on spring Chinook salmon in the South Santiam.

**Table 3.8-35. South Santiam Alternative 2A spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Fails | Fails | NA |
| IPA | Meets | Meets | Meets | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 2 | 2 | NA | 3 |
| EDT Normal | 3 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Steelhead**

The performance metrics for winter steelhead in the South Santiam under Alternative 2A are summarized in Table 3.8-36. Steelhead performance between both models demonstrated similar patterns as Chinook predictions. The LCM predicted non-viability with respect to productivity and quasi-extinction risk while the IPA predicted meeting viability thresholds for median spawner abundance and productivity. Recall that the LCM predicted 0.0 productivity in the South Santiam in all alternatives despite demonstrating low extinction risk in some alternatives (see section 3.8.2.4.2 Chinook). The IPA produced results similar to those for Chinook. This likely reflects improved downstream passage, improved habitat opportunities below dam, and reduced prespawn mortality with temperature control measure. EDT produced identical patterns with respect to Alternative 2A resiliency by water year type (see Chinook). It is expected that Alternative 2A would have MINOR adverse impacts on winter steelhead in the South Santiam.

**Table 3.8-36. South Santiam Alternative 2A winter steelhead performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Fails | Fails | NA |
| IPA | Meets | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

### *3.8.2.5.3 McKenzie*

Under Alternative 2A, construction of structural downstream fish passage (#392) would be implemented at Cougar. Upstream passage would occur using the existing adult fish collection facility at the base of Cougar Dam. The structural fish passage improvements allow Chinook and bull trout to access habitat above and below Cougar Dam, supporting increased Chinook abundance and productivity compared to the NAA, and increased survival of bull trout seeking to pass downstream.

**Chinook**

The performance metrics for spring Chinook in the McKenzie under Alternative 2A are summarized in Table 3.8-37. Alternative 2A proposes a structure at Cougar which assumes more optimistic downstream survival, particularly in the LCM. Both life cycle models predict viability in all performance metric dimensions. Similar to Alternative 1, EDT predicts similar performance over hydrology year type with respect to diversity which is likely due to the presence of multiple life history types above and below Cougar. However, Alternative 2A performs worse in dry and normal year types as opposed to wet years. Alternative 2A presents reduced overall risk due to effective downstream passage, adequate temperature control, and the presence of self-sustaining population downstream of Cougar. It is expected that Alternative 2A would have MINOR adverse impacts on spring Chinook salmon in the McKenzie.

**Table 3.8-37. McKenzie Alternative 2A spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Fails | Meets | NA |
| IPA | Meets | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 3 | NA | 1 |
| EDT Normal | 2 | 2 | NA | 1 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Bull Trout**

The performance metrics for bull trout in the McKenzie under Alternative 2A are summarized in Table 3.8-38. In general, bull trout are able to take advantage of habitat above and below Cougar due to structural downstream passage at Cougar dam and the adult facility in the tailrace of Cougar. However, given that the population above Cougar has been stable for many years, there is a moderate risk from passage if adults that are moved downstream. The rate of downstream passage of bull trout will not be understood until the structural passage improvement is operated for several years. Regardless, individual bull trout moved below the dam must be collected and moved back above the dam to contribute to the spawning population above the dam, otherwise these individuals are a loss to the population, reducing abundance and productivity. Bull trout that moved below Cougar would be subject to downstream effects and limiting factors. It is expected that Alternative 2A would have MODERATE impacts on bull trout in the McKenzie.

**Table 3.8-38. Summary of bull trout habitat scoring and relative risk under Alternative 2A in the McKenzie**

| Sub-basin | Region | Score | Demographic Risk |
|---|---|---|---|
| McKenzie | Above Cougar (rearing/foraging and spawning) | 12.15 | Moderate |
| | Below Cougar (rearing/foraging only) | 14.73 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

### *3.8.2.5.4 Middle Fork*

Under Alternative 2A, the existing adult facility at Fall Creek Dam in combination with the operational downstream passage by way of a fall reservoir deep drawdown will support maintaining the re-established Chinook sub-population above Fall Creek Dam. Construction of structural downstream fish passage (#392) would be implemented at Lookout Point Dam but not Hills Creek Dam. Upstream passage would occur using the existing adult fish facility at the base of Dexter Dam. The structural fish passage improvements allow Chinook to access habitat above Lookout Point Dam, supporting increased abundance and productivity compared to the NAA. The existing adult facility at Fall Creek Dam in combination with the operational downstream passage by way of a fall reservoir deep drawdown will support maintaining the re-established Chinook sub-population above Fall Creek Dam. At Hills Creek Dam, downstream passage occurs through existing outlets where on average downstream fish passage survival is low under the NAA dam operational regime. The existing bull trout population above Hills Creek Dam would be expected to perform the same as under the NAA.

**Chinook**

The performance metrics for spring Chinook salmon in the Middle Fork under Alternative 2A are summarized in Table 3.8-39. The IPA and LCM predict viability with respect to equilibrium spawner abundance and recruits per spawner but not with respect to quasi-extinction risk. This pattern occurs when a population is productive but only at extremely low abundance. This indicates that the population may never meet the abundance threshold required to limit demographic risk. It is important to note that Alternative 2A produced low mean persistence in both the IPA and the LCM and these estimates are well below acceptable thresholds for viability, despite demonstrating improvement over the No Action Alternative. The EDT output produced typical results with respect to equilibrium spawner abundance and quasi-extinction risk (i.e., the alternative performed better in wet years than in normal or dry). Surprisingly, dry years performed better than normal years with respect to recruit per spawner. It is likely that effective downstream passage improves performance somewhat but lack of adequate temperature control may contribute to ongoing prespawn mortality above and below the project. It is expected that Alternative 2A would have MAJOR adverse impacts on spring Chinook salmon in the Middle Fork.

**Table 3.8-39. Middle Fork Alternative 2A spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Meets | Fails | NA |
| IPA | Meets | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 3 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Bull Trout**

The performance metrics for bull trout in the Middle Fork under Alternative 2A are summarized in Table 3.8-40. Alternative 2A does not propose up or downstream passage at Hills Creek Dam. Given that the population above Hills Creek Dam has been increasing in recent years (Zymonas et al. 2021), the demographic risk to the bull trout population above Hills Creek is low. Although bull trout that move downstream are not able to re-enter the spawning population above the dam, the population has been growing under similar operational conditions as assumed for this alternative. Therefore the population performance would not be expected to change. Since most bull trout remain upstream of Hills Creek Dam, they are not exposed to risks associated with poorer habitat conditions, angling, passage at other dams and other human-related factors. It is expected that Alternative 2A would have NEGLIGIBLE impacts to bull trout in the Middle Fork.

**Table 3.8-40. Summary of bull trout habitat scoring and relative risk under Alternative 2A in the Middle Fork**

| Sub-basin | Region | Score | Demographic Risk |
|---|---|---|---|
| Middle Fork | Above Hills Creek (rearing/foraging and spawning) | 10.11 | Low |
| | Below Hills Creek (rearing/foraging only) | 0 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

### *3.8.2.5.5 Near-term Operations Measure for Alternatives 2A, 2B, 3A, 3B, 4, 5*

The descriptions of the near-term operations measure can be found within Chapter 2. The analysis of impacts of the near-term operations measure on ESA-listed fish is broken down into subbasins.

**North Santiam Subbasin**

The near-term operations measure within the North Santiam Basin includes Fall/Winter downstream fish passage through the upper regulating outlets and spring fish passage through strategic use of spillway and turbines at Detroit Dam and spreading spill to reduce total dissolved gas at Big Cliff Dam.

***Effects on UWR Steelhead from spring/summer spill operation:***

UWR steelhead are not currently passed upstream of Detroit Dam, and there would be no plans to begin doing so until the long-term downstream passage solution is implemented. Therefore, effects of this action would be limited to steelhead downstream of Big Cliff Dam in the North Santiam River.

Upstream Passage Rates and Survival: Under this action, upstream migrating fish will continue to be collected at the Minto Adult Fish Collection Facility, where they can be loaded onto a truck and translocated to the North Santiam River Reach between Minto and Big Cliff dams. There are no changes from the NAA expected with implementation of this near term action on adult collection rates. Exposure to elevated TDG levels could increase for adults translocated between Minto and Big Cliff dams, however this would be expected to be minimal since adults are highly mobile and can avoid prolonged exposure.

Incubation and rearing: Natural origin adult winter steelhead will continue to be released into the Minto Dam to Big Cliff Dam reach of the North Santiam to spawn. Incubation periods overlap with this operation. The NAA also assumes surface spill occurs in the spring and summer for temperature control purposes. Since spill under this action may begin sooner than those in the NAA for temperature control, effects from elevated TDG on incubating eggs and fry may be somewhat higher in comparison to the NAA. Juveniles rearing below Big Cliff Dam could be exposed to high TDG however this is expected to be minimal since juvenile are highly mobile and can avoid exposure by moving within the local river channel, or moving downstream where high TDG levels are known to dissipate.

***Effects on UWR Chinook from spring/summer spill operation:***

Upstream Passage Rates and Survival: Under this action, upstream migrating marked (hatchery) adult fish will continue to be collected at the new Minto Adult Fish Collection Facility, where they can be loaded onto a truck and translocated above Detroit Dam. Unmarked (natural origin) adult Chinook would continue to be released above Minto Dam. There are no changes from the NAA expected with implementation of this near term action on adult collection rates. Exposure to elevated TDG levels could increase for adults migrating upstream to Minto, and particularly for natural origin adults released into the reach between Minto and Big Cliff. This exposure is not expected to increase pre-spawn mortality rates since adults are highly mobile and can avoid prolonged exposure.

Incubation and rearing: Natural origin adult spring Chinook will continue to be released into the Minto Dam to Big Cliff Dam reach of the North Santiam to spawn. Surface spill is not expected to occur during or after the Chinook spawning season from Detroit Dam. Therefore, the effect on incubation and rearing is expected to be the same as assumed for the NAA.

Downstream passage rates and survival: Beeman and Adams (2015) estimated survival from the forebay of Detroit Dam to Big Cliff forebay as 71.6% based on detections of acoustic tagged juvenile Chinook. Their study did not account for route of passage, however most of the fish passage events detected occurred during the period when surface spill was occurring and those fish with known routes of passage nearly all used the spillway.

In 2021, rotary screw traps were used to collect fish moving downstream from Big Cliff Dam when Detroit and Big Cliff dams' operations were similar to the near-term operations were conducted. Catch rates of juvenile Chinook salmon were low during spring when some surface spill occurred, and then highest during the month of July in a period when no spill occurred (Cramer Fish Sciences 2022). This may be related to the timing of juvenile Chinook entering the forebay, given previous reservoir distribution studies by ODFW show most juveniles remain very close to shore in the upper half of the reservoir until summer (Monzyk et al. 2014), and therefore few may be available to pass downstream until they become more dispersed in the reservoir during early summer. Catch rates reported from screwtraps need to be interpreted with caution since they vary considerably within and between years, and typically the catch rates of screwtraps are extremely low (<5%). Monitoring data from screwtraps also rarely permit an estimate of the numbers of fish passing downstream during the targeted operational period due to the extremely low catch rates, do not permit an assessment of which routes through the dam that were used to pass, or the survival of those passing.

The number of days that surface spill can occur depends on the annual hydrology. In some years surface spill may continue into July or August. In those years, more juvenile Chinook would be expected to pass downstream and survive at a higher rate compared to years when spill duration is less. Downstream flow minimum targets per Measure 30 will increase the reservoir refill rate in spring and increase the probability of surface spill occurring among years and the duration it occurs.

Juvenile fish passing downstream of Detroit Dam must also pass-through Big Cliff Reservoir and Dam. Beeman and Adams (2015) estimated juvenile Chinook survival from Detroit Dam tailrace downstream to Minto Dam as 67-74 percent, or inversely a mortality of 26-33 percent. We assume this estimate includes mortality occurring below Big Cliff Reservoir. Fischer et al. 2019 estimated mortality through Dexter Reservoir (which reregulates flows below Lookout Point Dam), at about 2%. Big Cliff Reservoir is smaller than Dexter. Oligher and Donaldson (1966) conducted Big Cliff Kaplan turbine unit tests to determine what effect various operating conditions would have on survival of fish passing through this type of turbine. Average survival from all tests in Oct. 1964 was 91.1 percent at 91 ft. head, 94.5 percent at 81 ft. head, and 89.7 percent at 71 ft. head. Average survival from all tests in May 1966 was 92.2 percent at 91 ft. head, 89.8 percent at 81 ft. head, and 90.6 percent at 71 ft. head. Therefore, we expect the 26-

33 percent mortality rate range is likely high since it also includes mortality occurring below Big Cliff.

Based on review of the recent monitoring collected using screwtraps and previous screwtrapping results, it is assumed the near-term action will result in an increase in surface spill and consequently downstream passage rates and survival for juvenile Chinook in comparison to the NAA.

Hatchery Program and effects on ESA-listed natural origin production: The HGMP (2016) for the North Santiam hatchery spring Chinook program indicates until the long-term juvenile fish passage solution past Detroit is implemented and approved by NMFS that only hatchery UWR Chinook salmon will be transported above Detroit Dam unless genetic pedigree indicates there is greater than a 1:1 ratio of recruits to spawners in the pedigree data for adults released above the dams for five complete years of data, or if fish managers determine there are special circumstances leading to a decision to outplant natural origin adults above Detroit Dam (e.g., lower survival of adults or their progeny is expected due to weather or habitat conditions below dams). Therefore, we conclude that pHOS will in most, if not all years, remain at 100% above the dam during implementation of this near-term action, and will remain the same as below Minto Dam as under the NAA.

***Effects on UWR Steelhead during the fall/winter operation:***

UWR steelhead are not currently passed upstream of Detroit Dam, and there would be no plans to begin doing so until long-term downstream passage is implemented. Therefore, effects of this action would be limited to steelhead downstream of Big Cliff Dam in the North Santiam River.

Upstream Passage Rates and Survival: Under this action, upstream migrating fish will continue to be collected at the new Minto Adult Fish Collection Facility, where they can be loaded onto a truck and translocated and released into the river between Minto and Big Cliff dams. There are no changes from the NAA expected with implementation of this near-term action on adult collection rates. Exposure to elevated TDG levels could increase for adults translocated between Minto and Big Cliff dams, however this would be expected to be minimal since adults are highly mobile and can avoid prolonged exposure.

Incubation and rearing: Natural origin adult winter steelhead will continue to be released into the Minto Dam to Big Cliff Dam reach of the North Santiam to spawn. Incubation periods do not overlap with this operation therefore effects are the same as those assumed for the NAA. Juveniles rearing below Big Cliff Dam could be exposed to high TDG however this is expected to be minimal since juveniles are highly mobile and can avoid exposure by moving within the local river channel or moving downstream where high TDG levels are known to dissipate.

***Effects on UWR Chinook during the fall/winter operation:***

Upstream Passage Rates and Survival: Under this action, upstream migrating marked (hatchery) fish will continue to be collected at the new Minto Adult Fish Collection Facility, where they can be loaded onto a truck and translocated above Detroit Dam. Unmarked (natural origin) fish would be released into the river between Minto and Big Cliff dams. There are no changes from the NAA expected with implementation of this near-term action on adult collection rates. Exposure to elevated TDG levels could increase for adults migrating upstream to Minto, and particularly for natural origin adults released into the reach between Minto and Big Cliff. This exposure is not expected to increase pre-spawn mortality rates since adults are highly mobile and can avoid prolonged exposure.

Incubation and rearing: Natural origin adult spring Chinook will continue to be released into the Minto Dam to Big Cliff Dam reach of the North Santiam to spawn. Exposure to elevated TDG levels could increase for incubating eggs and fry as a result of this near-term measure. If TDG levels are high enough and exposure duration long enough, injury or mortality can be expected. Data is not available to quantify this potential effect.

Downstream passage rates and survival: Beeman and Adams (2015) estimated survival from the forebay of Detroit Dam to Big Cliff forebay at 62.2% in the fall of 2013 when 120 of 122 fish that passed used the turbines. Turbine flows were generally greater than 1000 cfs. For regulating outlets (ROs), Alden (2014) summarized survival rates, which were based on Normandeau (2010) using rainbow trout as a surrogate for subs/yearlings in their study. Based on this information, survival rates for sub-yearling and yearling Chinook passing through the RO would be expected to range between 70% and 95%. If additional juvenile Chinook pass through the RO than the turbines under this operation in comparison to the NAA, this could result in an increase in survival. It is uncertain however if passage rates through the RO will increase with this action, or if juveniles will instead pass through the turbines during the day because the reservoir elevation over the RO will remain high.

Monitoring recently occurred using rotary screw traps to collected fish moving downstream from Big Cliff Dam when Detroit and Big Cliff dams were operated in the fall 2021 similar to the near-term action. Catch rates of juvenile spring Chinook salmon increased in the late fall (Cramer Fish Sciences 2022), as observed in previous years (Romer et al. 2016). There did not appear to be any clear relationships between dam operations at Detroit Dam and catch of juvenile Chinook salmon below Big Cliff Dam (Cramer Fish Sciences 2022). Catch rates reported from screwtraps need to be interpreted with caution since they vary considerably within and between years, and typically they are less than 3%. This monitoring data also does not permit an estimate of the numbers of fish passing downstream during the targeted operational period, which routes through the dam in operations that were used to pass, or survival of those passing.

Juvenile fish passing downstream of Detroit Dam must also pass-through Big Cliff Reservoir and Dam. Beeman and Adams (2015) estimated juvenile Chinook survival from Detroit Dam tailrace downstream to Minto Dam as 67% to 74%, or inversely a mortality of 26% to 33%. We assume this estimate includes mortality occurring below Big Cliff Reservoir. Fischer et al. 2019 estimated mortality through Dexter Reservoir (which reregulates flows below Lookout Point Dam), at about 2%. Big Cliff Reservoir is smaller than Dexter. Oligher and Donaldson (1966) conducted Big Cliff Kaplan turbine unit tests to determine what effect various operating conditions would have on survival of fish passing through this type of turbine. Average survival from all tests in Oct. 1964 was 91.1 percent at 91 ft. head, 94.5 percent at 81 ft. head, and 89.7 percent at 71 ft. head. Average survival from all tests in May 1966 was 92.2 percent at 91 ft. head, 89.8 percent at 81 ft. head, and 90.6 percent at 71 ft. head. Therefore, we expect the 26%-33% mortality rate range is likely high since it also includes mortality occurring below Big Cliff.

Based on review of the recent information collected using screwtraps and previous screwtrapping results, it is assumed the near-term action will result in similar passage rates and some improvement in downstream passage survival for juvenile Chinook in comparison to the NAA.

Hatchery Program and effects on ESA-listed natural origin production: The HGMP (2016) for the North Santiam hatchery spring Chinook program indicates until the long-term juvenile fish downstream passage solution at Detroit is implemented and approved by NMFS that only hatchery UWR Chinook salmon will be transported above Detroit Dam unless genetic pedigree indicates there is greater than a 1:1 ratio of recruits to spawners in the pedigree data for adults released above the dams for five complete years of data, or if fish managers determine there are special circumstances leading to a decision to outplant natural origin adults above Detroit Dam (e.g. lower survival of adults or their progeny is expected due to weather or habitat conditions below dams). Therefore we assume pHOS will in most, if not all years, will remain at 100% above the dam during implementation of this near-term action, and will remain the same below Minto Dam as under the NAA.

**South Santiam Subbasin**

The near-term operations measure within the South Santiam Subbasin include outplanting of adult Chinook above Green Peter Reservoir, downstream fish passage at Green Peter Dam via the spillway in the spring and fall, and downstream fish passage at Foster via the spillway in the spring and fall.

Effects on UWR Steelhead from spring/summer spill operation:

UWR steelhead are passed upstream of Foster Dam but not Green Peter Dam, and there would be no plans to begin doing until a long-term downstream passage solution is implemented at Green Peter. Therefore, effects of this action would be limited to steelhead downstream of Green Peter Dam in the South Santiam River.

Upstream Passage Rates and Survival: Under this action, upstream migrating fish will continue to be collected at the Foster Adult Fish Collection Facility, where they can be loaded onto a truck and translocated above Foster Dam. There are no changes from the NAA expected with implementation of this near term action on adult collection rates. Exposure to elevated TDG would be same as under the NAA.

Incubation and rearing: Natural origin adult winter steelhead will continue to be released above Foster Dam. Exposure of eggs and fry to elevated TDG below Foster Dam would be same as under the NAA.

Downstream Passage and Survival: Juvenile winter steelhead would experience the same passage conditions as exists in the NAA, and therefore there would be no change in effects expected.

***Effects on UWR Chinook from spring/summer spill operation:***

Upstream Passage Rates and Survival: Under this action, upstream migrating fish will continue to be collected at the Foster Adult Fish Collection Facility, where they can be loaded onto a truck and translocated above Foster or Green Peter dams. Unmarked adults will be released above Foster Dam, and adult hatchery fish would be transported and released above Green Peter Dam or taken as brood for hatchery production. Beginning four years after hatchery adults are released upstream of Green Peter Dam, surviving adult progeny will begin returning to Foster Dam. These returning adult progeny will be unmarked and will either need to be held and genetically tested to determine if they originated above Green Peter or released to spawn with natural origin fish above Foster. If the former approach is taken, there is a risk that pre-spawn mortality rates could increase from increased handling and delayed passage upstream. If the latter approach is taken, this could decrease fitness of the wild population occurring above Foster Dam. However, this genetic effect is expected to be similar to that which occurs under the NAA since many progeny returning from naturally spawning hatchery fish already occurs in the Sub-basin considering the high level of pHOS below Foster Dam, and since up to 30% of the unmarked outplanted Chinook have been found to be hatchery origin.

Incubation and rearing: No changes in effects would be expected when compared to the NAA for Chinook spawned above or below Foster Dam. Offspring of adult hatchery Chinook outplanted above Green Peter will now rear upstream or within Green Peter Reservoir prior to seeking to pass downstream of Green Peter Dam.

Downstream passage rates and survival: Data is not available on the passage rates or survival of juvenile Chinook at Green Peter Dam. Since the dam has a similar configuration to Detroit Dam, passage and survival rates are expected to be similar when depths to outlets and discharge rates are similar. Juvenile passage survival rates for Chinook are expected to be intermediate between those assessed under Alternatives 2A, 2B and 3A at Green Peter and Foster Dams.

Hatchery Program and effects on ESA-listed natural origin production: The HGMP (2016) for the South Santiam hatchery spring Chinook program states the outplanting protocols have not been fully developed. We assume they would be similar to the North Santiam. Until the long-term juvenile fish passage solution for downstream fish passage at Green Peter is implemented and approved by NMFS, we assume that only hatchery UWR Chinook salmon will be transported above Green Peter Dam unless genetic pedigree indicates there is greater than a 1:1 ratio of recruits to spawners in the pedigree data for adults released above the dams for five complete years of data, or if fish managers determine there are special circumstances leading to a decision to outplant natural origin adults above Green Peter Dam (e.g. lower survival of adults or their progeny is expected due to weather or habitat conditions below dams). Therefore we conclude that pHOS will in most, if not all years, will remain at 100% above the dam during implementation of this near-term action, and will remain the same below Foster Dam as under the NAA.

Based on the above considerations, it is assumed the near-term action may increase returns of unmarked adult Chinook as a result of outplanting hatchery adult Chinook above Green Peter Dam and providing surface spill for downstream passage. As a result of surface spill from Green Peter, water temperatures in Foster Reservoir and in the South Santiam below Foster Dam could be warmer at times and very similar to those assessed under Alternative 2A, 2B and 3A. Other effects are expected to be very similar to the NAA.

**Long Tom Subbasin**

There are no local operations proposed under the near-term operations measure within the Long Tom subbasin, therefore, there would be no effects of this measure to ESA-listed spring Chinook salmon, winter steelhead or bull trout in this subbasin.

**McKenzie Subbasin**

The near-term operations measure within the McKenzie Subbasin includes that Cougar reservoir will have a drawdown target below minimum conservation elevation (1532 ft) during the spring (1505 ft) and fall (1520 ft). The operation also limits releases to less than about 900 cfs for water quality concerns. This results in the reservoir only meeting the drawdown target elevations in dry years and only for relatively brief periods.

***Effects on UWR Chinook from spring/summer spill operation:***

The near-term operation is very similar to those included in Alternative 3A for Cougar Dam, however the fall reservoir elevation target is 1520 instead of 1505.

Upstream Passage Rates and Survival: Under this action, upstream migrating fish will continue to be collected at the Cougar Adult Fish Collection Facility, where they can be loaded onto a truck and translocated above Cougar Dam. The extent and timing that Cougar Reservoir will be refilled will affect water temperatures downstream. Water temperatures and their effects on adult Chinook migration and pre-spawn mortality would be expected to be similar to Alternative 3A given the similarities with the near-term operation.

Incubation and rearing: Discharge rates and water temperatures from Cougar Dam resulting from the near-term operation may affect incubation of Chinook below Cougar Dam. These effects would be expected to be similar to Alternative 3A given the similarities with the near-term operation.

Downstream passage rates and survival: Effects in spring would be assumed to be the same as assessed for Alternative 3A. In the fall, the reservoir elevation target is 15 ft higher. This elevation change could reduce juvenile Chinook passage rates and survival somewhat compared to effects assessed in alternative 3A.

Monitoring occurred using rotary screw traps to collect fish moving downstream from Cougar Dam for operations in the fall of 2021 that are similar to the near-term operations proposed (Cramer Fish Sciences 2022). Catch rates of juvenile Chinook salmon were low during spring and summer when most flow was through the turbine penstocks. In fall, catch rates of juvenile Chinook increased between early October and mid-November, when more water was passed through the RO. This pattern in catch rates is very similar to those observed in previous years (Romer et al. 2013, 2014, 2015, 2016). Catch rates reported from screwtraps need to be interpreted with caution since they vary considerably within and between years, and typically catch rates of screwtraps are extremely low (<5%). Monitoring data from screwtraps also rarely permits an estimate of the numbers of fish passing downstream during the targeted operational period due to the extremely low catch rates, and also does not permit assessment of which routes through the dam in operation that were used to pass or the survival of those passing.

Hatchery Program and effects on ESA-listed natural origin production: Effects of the near-term operations on outplanting of adult hatchery Chinook above Cougar Dam and on pHOS levels above and below Cougar Dam in the McKenzie Sub-basin would be expected to be the same as assessed under Alternative 3A.

Based on the above considerations, as a result of drafting the reservoir in spring and fall and use of the RO, juvenile passage and survival rates are expected to improve somewhat in comparison to the NAA, similar to that assessed in Alternative 3A. Under these improvements it is assumed the near-term action may increase returns of unmarked adult Chinook as a result of outplanting hatchery adult Chinook above Cougar Dam. Other effects of this measure are assumed to be the same as those assessed for Alternative 3A at Cougar Dam for spring Chinook salmon.

***Effects on McKenzie Sub-basin bull trout from spring/summer spill operation:***

Effects of the near-term action on bull trout would also be similar to those assessed for Alternative 3A. Operations could allow more bull trout to pass below the dam and utilize additional rearing/foraging habitat. Those moving downstream however must survive, and then be trapped and trucked back upstream in order to contribute to the population. Demographic risks of bull trout moving downstream would be considered moderate for the currently stable population of bull trout above Cougar Dam since many bull trout would likely continue to rear in the reservoir and spawn upstream.

**Middle Fork Willamette River Subbasin**

The near-term operations measure within the Middle Fork Willamette Subbasin includes prioritized use of the regulating outlet for downstream fish passage at Hills Creek in fall, use of the spillway for fish passage at Lookout Point in the spring, deep drawdown for fish passage at Lookout Point in fall, and deep drawdown for fish passage in the fall at Fall Creek. For the operations at Lookout Point, storage at Hills Creek would be used for refilling Lookout Point in early March. The existing adult facility at Fall Creek Dam in combination with the operational downstream passage by way of a fall reservoir deep drawdown will support maintaining the re-established Chinook sub-population above Fall Creek Dam.

***Effects on UWR Chinook from spring/summer operations:***

The near-term operation is very similar to those included in Alternative 3B for fish passage at Lookout Point Dam and Hills Creek Dam, however there is not a delayed refill/deep drawdown of Hills Creek Reservoir in spring. Instead, refill will be affected by using Hills Creek storage for refilling Lookout Point Reservoir in early March with maximum pool elevations dictated by the rule curve for Hills Creek Reservoir.

Upstream Passage Rates and Survival: Under this action, upstream migrating adult Chinook salmon will continue to be collected at the Dexter Adult Fish Collection Facility, where they can be sorted and either taken for hatchery brood stock or loaded onto a truck and translocated above WVS dams to spawn naturally. The extent and timing that Hills Creek and Lookout Point Reservoirs will be refilled will affect water temperatures downstream. Water temperatures and their effects on adult Chinook migration and pre-spawn mortality would be expected to be similar to Alternative 3A given the similarities with the near-term operation.

Incubation and rearing: Discharge rates and water temperatures from Lookout Point and Hills Creek dams resulting from the near-term operation can affect incubation of Chinook below each dam. These effects would be expected to be similar to Alternative 3A given the similarities with the near-term operations.

Downstream passage rates and survival: For juvenile Chinook salmon, effects in spring would be assumed to be the very similar as assessed for Alternative 3A at Lookout Point in the spring and fall. At Hills Creek, passage and survival rates will be like those assessed for the NAA. In the fall, passage and survival rates will be like those assessed for Alternative 3A and 3B. For both dams, juvenile downstream passage rates and survival are expected to increase compared to the NAA.

Hatchery Program and effects on ESA-listed natural origin production: Effects of the near-term operations on outplanting of adult hatchery Chinook above Lookout and Hills Creek dams and on pHOS levels above and below these dams in the Middle Fork Sub-basin would be expected to be the same as assessed under Alternative 3A and 3B. Increases in unmarked (natural origin) Chinook salmon to the sub-basin resulting from improved downstream passage may reduce pHOS somewhat above dams, however outlplanting of hatchery adult Chinook will likely continue. No change in pHOS is expected below Lookout Point dam compared to the NAA.

Based on the above considerations, juvenile passage and survival rates are expected to improve somewhat in comparison to the NAA, similar to that assessed in Alternative 3A. Under these improvements it is assumed the near-term action may increase returns of unmarked adult Chinook as a result of outplanting hatchery adult Chinook above Lookout Point and Hills Creek dams. Other effects of this measure are assumed to be the same as those assessed for Alternative 3A in the Middle Fork.

Effects on Middle Fork Sub-basin bull trout from interim operations:

Effects of the near-term action on bull trout would also be similar to those assessed for Alternative 3A or 3B. Operations could allow more bull trout to pass below the dam and utilize additional rearing/foraging habitat. Those moving downstream however must survive, and then be trapped and trucked back upstream in order to contribute to the population. Demographic risks of bull trout moving downstream of Hills Creek Dam would be considered high for the currently growing population of bull trout above Hills Creek Dam since currently bull trout rear in Hills Creek Reservoir and spawn upstream.

**Coast Fork Subbasin**

There are no local operations proposed under the near-term operations measure within the Coast Fork subbasin, therefore, there would be no effects of this measure to ESA-listed spring Chinook, winter steelhead or bull trout in this subbasin.

**Mainstem Willamette River**

Flows and water temperatures would be similar to the NAA, with additional releases for water temperature management. Flows and water temperatures as assessed provide for improved water temperatures and maintain habitat conditions for migrating and rearing fish similar to the NAA, and at a much greater flow level in summer and early fall when compared to unregulated conditions. Peak winter flows are reduced for flood risk management at the same level as for the NAA, resulting in less floodplain habitat for juvenile fish present, or for channel-forming process which maintain and create habitat conditions for native fish.

Habitat improvements below WVP dams, specifically large wood placement and sediment placement will be completed as part of the near-term actions. Dams serve as a catchment for large woody debris and for sediments, decreasing the incidence of both in rivers downstream and disrupting sediment storage and fluvial processes. The placement of both large woody debris and sediments in downstream reaches would increase habitat complexity and subsequently provide an increase in suitable rearing and spawning habitat for UWR Chinook and steelhead.

### 3.8.2.6 Alternative 2B

#### 3.8.2.6.1 North Santiam

In the North Santiam, measures being implemented for Alternative 2B are the same as those as for Alternative 2A. For downstream fish passage, construction of structural downstream fish passage (#392) would be implemented at Detroit Dam. For upstream passage, fish would be collected at the existing Minto adult fish facility and trucked upstream. The structural fish passage improvements allow Chinook and steelhead to access habitat above Detroit Dam, and support increased abundance and productivity compared to the NAA. Passage improvements would also support passage of a re-introduced bull trout population above Detroit Dam to access habitat below the dam and return back upstream to re-enter the spawning population, but there are a greater number of limiting factors downstream increasing potential for mortality for individuals that move downstream. Since there is not any spawning habitat available downstream of the dam, individuals must survival and migrate back upstream, be collected and trucked above Detroit Dam, in order to re-enter the spawning population.

**Chinook**

Effects of Alternative 2B to spring Chinook salmon in the North Santiam would be similar to effects described for Alternative 2A. See Table 3.8-41. Refer to Section 3.10.2.4.1 North Santiam for a description of the impacts to spring Chinook salmon in the North Santiam. Like Alternative 2A, Alternative 2B would be expected to have MINOR adverse impacts on spring Chinook salmon in the North Santiam.

**Table 3.8-41. North Santiam Alternative 2B spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Meets | Meets | NA |
| IPA | Meets | Meets | Meets | NA |
| EDT Wet | 1 | 1 | NA | 2 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 3 | NA | 1 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Steelhead**

Effects of Alternative 2B to winter steelhead in the North Santiam would be similar to effects described for Alternative 2A. See Table 3.8-42. Refer to Section 3.10.2.4.1 North Santiam for a description of the impacts to winter steelhead in the North Santiam. Like Alternative 2A, Alternative 2B would have MINOR adverse impacts to winter steelhead in the North Santiam.

**Table 3.8-42. North Santiam Alternative 2B winter steelhead performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Meets | Meets | NA |
| IPA | Meets | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Bull Trout**

Effects of Alternative 2B to bull trout in the North Santiam would be similar to effects described for Alternative 2A. See Table 3.8-43. Refer to Section 3.10.2.4.1 North Santiam for a description of the impacts to winter steelhead in the North Santiam. As with Alternative 2A, is expected that Alternative 2B would have MODERATE adverse impacts on bull trout in the North Santiam.

**Table 3.8-43. Summary of bull trout habitat scoring and relative risk under Alternative 2B in the North Santiam**

| Sub-basin | Region | Score | Demographic Risk |
|---|---|---|---|
| North Santiam | Above Detroit (rearing/foraging and spawning) | 42.47 | High |
| | Below Detroit (rearing/foraging only) | 38.48 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

### *3.8.2.6.2 South Santiam*

In the South Santiam, measures being implemented for Alternative 2B are the same as those as for Alternative 2A. For downstream fish passage at Foster Dam, construction of structural downstream fish passage (#392) would be implemented. At Green Peter Dam, a deeper fall reservoir drawdowns for fish passage (#40) and spring spill would be implemented to provide downstream fish passage. An adult fish facility would also be constructed at the base of Green Peter Dam. These fish passage improvements allow Chinook and steelhead to access habitat above both Foster and Green Peter dams, supporting the potential for increased abundance and productivity compared to the NAA. Compared to above other WVS dams, the relatively lower elevation habitat above these dams may constrain productivity and survival.

**Chinook**

Effects of Alternative 2B on spring Chinook salmon in the South Santiam would be similar (but not identical) to effects described for Alternative 2A. See Table 3.8-44. Refer to Section

3.10.2.4.2 South Santiam for a description of the impacts to spring Chinook salmon in the South Santiam. It is predicted that like Alternative 2A, Alternative 2B would have MINOR adverse impacts on spring Chinook salmon in the South Santiam.

**Table 3.8-44. South Santiam Alternative 2B spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Fails | Fails | NA |
| IPA | Meets | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 2 | 2 | NA | 3 |
| EDT Normal | 3 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Steelhead**

Effects of Alternative 2B on winter steelhead in the South Santiam would be similar to effects described for Alternative 2A. See Table 3.8-45. Refer to Section 3.10.2.4.2 South Santiam for a description of the impacts to winter steelhead in the South Santiam. It is expected that like Alternative 2A, Alternative 2B would have MINOR adverse impacts on winter steelhead in the South Santiam.

**Table 3.8-45. South Santiam Alternative 2B winter steelhead performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Meets | Meets | NA |
| IPA | Meets | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

### *3.8.2.6.3 McKenzie*

Under Alternative 2B, the diversion tunnel at Cougar would be used for downstream passage. The reservoir will be drafted to 25 feet over the diversion tunnel during both spring and fall. This will results in a very small residual reservoir pool during these season, and limited opportunity to refill the reservoir to supplement downstream flows during spring to fall seasons. Most Chinook would be expected to pass downstream as fry in spring. It is uncertain how bull trout may respond, however some would be expected to move upstream of the reservoir while others downstream. Forage opportunity will change over time for bull trout with repeated reservoir deep drawdowns, with the potential for less prey food availability in the reservoir potentially requiring bull trout to move downstream.

**Chinook**

Alternative 2B differs from Alternative 2A in how downstream passage is implemented at Cougar. In Alternative 2B, fish are passed through a diversion tunnel at Cougar. The performance metrics for spring Chinook salmon in the McKenzie under Alternative 2B are summarized in Table 3.8-46. The life cycle models disagree in two dimensions: recruits per spawner and quasi-extinction risk. Interestingly, the LCM predicts a lower productivity but a corresponding low extinction risk. This may reflect the timeline that the LCM considers below dam natural origin populations as well as above dam natural origin spawners. More extreme operations may have impacts on viable populations downstream. Again, the EDT output predicts resiliency in the life history diversity parameter but expected performance for recruits per spawner and equilibrium spawner abundance. Under Alternative 2B, spring Chinook in the McKenzie benefit from increased passage rates through the diversion tunnel and adequate temperature control to manage prespawn mortality and better attract upmigrating adults to the Cougar adult facility. Extreme drawdowns to the diversion tunnel may impact the ability to control downstream flows and habitat opportunities downstream for outmigrating juveniles and self-sustaining populations below the project. It is expected that Alternative 2B will have MODERATE adverse impacts on spring Chinook salmon in the McKenzie.

**Table 3.8-46. McKenzie Alternative 2B spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Fails | Fails | NA |
| IPA | Fails | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 3 | NA | 1 |
| EDT Normal | 2 | 2 | NA | 1 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Bull Trout**

The performance metrics for bull trout in the McKenzie under Alternative 2B are summarized in Table 3.8-47. In general, there are good habitat opportunities above and below Cougar. However, the uncertainty about the effectiveness of passage through the diversion tunnel poses high demographic risk if bull trout forage opportunity is decreased due to reservoir drawdowns or, if those moving downstream do not get collected and moved back upstream of Cougar Dam to spawn. Cougar Reservoir would largely be drained in spring and only partially refilled in summer, resulting in significant reduction in rearing/foraging opportunity within the reservoir. Many bull trout would be expected to move upstream into the South Fork McKenzie, or below Cougar Dam to rear. Suitable habitat for bull trout exists above and below Cougar Dam and Reservoir, however carry capacity and other effects of redistribution on survival and spawning is uncertain. It is expected that Alternative 3B would have MODERATE adverse impacts on bull trout in the McKenzie.

**Table 3.8-47. Summary of bull trout habitat scoring and relative risk under Alternative 2B in the McKenzie**

| Sub-basin | Region | Score | Demographic Risk |
|---|---|---|---|
| McKenzie | Above Cougar (rearing/foraging and spawning) | 12.16 | Moderate |
| | Below Cougar (rearing/foraging only) | 14.74 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

### *3.8.2.6.4 Middle Fork*

Fish passage conditions are the same as under Alternative 2A. The existing adult facility at Fall Creek Dam in combination with the operational downstream passage by way of a fall reservoir deep drawdown will support maintaining the re-established Chinook sub-population above Fall Creek Dam. Construction of structural downstream fish passage (#392) would be implemented at Lookout Point Dam but not Hills Creek Dam. Upstream passage would occur using the existing adult fish facility at the base of Dexter Dam. The structural fish passage improvements allow Chinook to access habitat above Lookout Point Dam, supporting increased abundance and productivity compared to the NAA. The existing adult facility at Fall Creek Dam in combination with the operational downstream passage by way of a fall reservoir deep drawdown will support maintaining the re-established Chinook sub-population above Fall Creek Dam. At Hills Creek Dam, downstream passage occurs through existing outlets where on average downstream fish passage survival is low under the NAA dam operational regime. The existing bull trout population above Hills Creek Dam would be expected to perform the same as under the NAA.

**<u>Chinook</u>**

Effects of Alternative 2B to spring Chinook salmon in the Middle Fork will be similar to effects described for Alternative 2A. See Table 3.8-48. Refer to Section 3.10.2.4.4 Middle Fork for a description of the impacts to spring Chinook salmon in the Middle Fork. It is expected that like Alternative 2A, Alternative 2B would have MAJOR adverse impacts on spring Chinook salmon in the Middle Fork.

**Table 3.8-48. Middle Fork Alternative 2B spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Meets | Fails | NA |
| IPA | Meets | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 3 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Bull Trout**

Effects of Alternative 2B to bull trout in the Middle Fork will be similar to effects described for Alternative 2A. See Table 3.8-49. Refer to Section 3.10.5.5 Middle Fork for a description of the impacts to bull trout in the Middle Fork. It is expected that like Alternative 2A, Alternative 2B would have NEGLIGIBLE impacts to bull trout in the Middle Fork.

**Table 3.8-49. Summary of bull trout habitat scoring and relative risk under Alternative 2B in the Middle Fork**

| Sub-basin | Region | Score | Demographic Risk |
|---|---|---|---|
| Middle Fork | Above Hills Creek (rearing/foraging and spawning) | 10.11 | Low |
| | Below Hills Creek (rearing/foraging only) | 0 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

*3.8.2.6.5 Near-term Operations Measure for Alternatives 2A, 2B, 3A, 3B, 4, 5*

See Alternative 2A, Section 3.10.2.4.5, for a description of predicted potential effects due to the Near-Term Operations Measure.

### *3.8.2.7 Alternative 3A*

*3.8.2.7.1 North Santiam*

Under Alternative 3A, at Detroit Dam a spring reservoir drawdown for downstream fish passage (#720) and deeper fall reservoir drawdowns for fish passage (#40) would be implemented for downstream passage. Upstream passage would be provided using the existing Minto adult fish facility where fish are collected and trucked upstream of the Detroit Dam.

**Chinook**

The performance metrics for spring Chinook salmon in the North Santiam under Alternative 3A are summarized in Table 3.8-50. The LCM predicts an inviable population with respect to productivity and quasi-extinction risk while the IPA predicts viability across all dimensions. The discrepancy between the two models is likely due to the aforementioned sensitivity of the LCM to structural versus operational downstream passage. The EDT output shows some resiliency with respect to diversity but not with respect to equilibrium abundance or recruits per spawner. This may reflect the availability of water to operate the alternative as intended in all year types. Under Alternative 3A, spring Chinook in Detroit may demonstrate improved performance over the No Action Alternative due to increased downstream passage rates. It is expected that extreme drawdown as proposed under Alternative 3A may impede the ability to control downstream flows for fish and limit the ability to accomplish temperature control. This may result in distorted emergence and run timing and may limit the ability to manage prespawn mortality. It is expected that Alternative 3A would have MODERATE adverse impacts on spring Chinook salmon.

**Table 3.8-50. North Santiam Alternative 3A spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Fails | Fails | NA |
| IPA | Meets | Meets | Meets | NA |
| EDT Wet | 1 | 3 | NA | 1 |
| EDT Dry | 3 | 1 | NA | 2 |
| EDT Normal | 2 | 2 | NA | 1 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Steelhead**

The performance metrics for winter steelhead in the North Santiam under Alternative 3A are summarized in Table 3.8-51. The life cycle models indicate a dissimilar pattern as for spring Chinook salmon. The patterns appear to be inverse among the two models with respect to each species. Again, both life cycle models disagree with respect to quasi-extinction risk but this may be attributable to the different timelines each model considers. This seems a less credible explanation since the LCM timeline is nearly 70 years longer in most cases. It is more likely that the IPA predicts poorer prognosis in the other dimensions (abundance and productivity). The EDT output indicate some resiliency with respect to recruit per spawner but not with respect to equilibrium spawner abundance or diversity. Similar to Chinook, while downstream passage rates are expected to increase under Alternative 3A, the ability to control downstream flows and temperature may be limited. This could result in emergence and migration timing shifts. It is expected that Alternative 3A would have MODERATE adverse impacts on winter steelhead in the North Santiam.

**Table 3.8-51. North Santiam Alternative 3A winter steelhead performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Meets | Meets | NA |
| IPA | Meets | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Bull Trout**

The performance metrics for bull trout in the North Santiam under Alternative 3A are summarized in Table 3.8-52. There would be adequate habitat available for bull trout above and below Detroit. However, the limited and potentially unsafe passage conditions at Detroit under Alternative 3A for bull trout could put the population at higher demographic risks if those fish attempting to move downstream were unable to return to the parent population to contribute to productivity. Demographic risk based on the hydrology, angling, and predation may be much higher, particularly if fish that pass below Detroit Dam do not survival or ultimately collected and trucked back upstream and spawn. It is expected that Alternative 3B would have MODERATE adverse impacts on bull trout in the North Santiam.

**Table 3.8-52. Summary of bull trout habitat scoring and relative risk under Alternative 3A in the North Santiam**

| Sub-basin | Region | Score | Demographic Risk |
|---|---|---|---|
| North Santiam | Above Detroit (rearing/foraging and spawning) | 42.79 | High |
| | Below Detroit (rearing/foraging only) | 28.44 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

### *3.8.2.7.2 South Santiam*

Under Alternative 3A, spring spill at Foster would continue to facilitate downstream passage. A deeper fall reservoir drawdown (#40) and spring spill would be implemented for downstream passage at Green Peter. An adult fish facility would also be constructed at the base of Green Peter Dam. These fish passage improvements allow Chinook and steelhead to access habitat above both Foster and Green Peter dams, supporting the potential for increased abundance and productivity compared to the NAA. Compared to above other WVS dams, the relatively lower elevation habitat above these dams may constrain productivity and survival.

**Chinook**

The performance metrics for spring Chinook salmon in the South Santiam under Alternative 3A are summarized in Table 3.8-53. In general, life cycle models agree that populations in the South Santiam would not be viable under Alternative 3. The EDT output demonstrates that this Alternative would likely not be resilient to annual hydrology. Similar to the No Action Alternative, spill for passage has been implemented at Foster. Under Alternative 3A, similar performance is expected due to limited downstream passage and lack of adequate temperature control which could contribute to ongoing prespawn mortality levels. At Green Peter, variability in operations and resulting passage rates may lead to uncertain performance; adult productivity above Green Peter is not well documented in the literature. For purposes of this exercise, it is assumed that productivity of spawners outplanted above Green Peter will be similar to those outplanted above Foster (since Foster fish will be the founding stock) but the rate of straying is unknow. It is expected that Alternative 3A would have MAJOR adverse impacts to spring Chinook salmon in the South Santiam.

**Table 3.8-53. South Santiam Alternative 3A spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Fails | Fails | NA |
| IPA | Meets | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 3 | NA | 3 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Steelhead**

The performance metrics for steelhead in the South Santiam under Alternative 3A are summarized in Table 3.8-54. Both life cycle models agree with respect to recruits per spawner and quasi-extinction risk. Equilibrium spawner abundance differs between the two models: the LCM predicts higher spawner abundance than the IPA; however, both models predict that this population would go extinct, even at higher equilibrium numbers. The EDT output indicate best performance in wet and normal years and slightly worse performance in dry years, likely because the system may not have enough water to operate as intended. Similar to Chinook, steelhead under Alternative 3A may experience lack of adequate downstream passage, particularly for kelts (repeat adult spawners) which are more vulnerable to spill operations due to the configuration of the spillway at Foster. Similar to Chinook, adult productivity above Green Peter is uncertain but assumed to be similar to spawners outplanted above Foster. It is expected that Alternative 3A would have MAJOR adverse impacts on winter steelhead in the South Santiam.

**Table 3.8-54. South Santiam Alternative 3A winter steelhead performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Fails | Fails | NA |
| IPA | Fails | Fails | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 2 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

### *3.8.2.7.3 McKenzie*

Under Alternative 3A, the regulating outlet at Cougar would be used to facilitate downstream passage. Upstream fish passage at Cougar Dam would occur using the existing fish facility at the base of the dam. A deeper fall reservoir drawdown (#40) would be implemented at Blue River for downstream passage and a new adult fish facility (#722) would be constructed to capture returning adults.

**Chinook**

The performance metrics for spring Chinook salmon in the McKenzie under Alternative 3A are summarized in Table 3.8-55. Both life cycle models indicate some elements of viability but taken together, operational passage at Cougar does not produce viable spring Chinook salmon populations. It is likely that the viability status under the LCM in the equilibrium spawner abundance category stems from the persistence of natural origin spawners downstream of Cougar dam. The EDT output indicates little resilience to hydrology year type except with respect to diversity. However, in other alternatives, EDT indicated that the diversity metric was resilient across water year type where Alternative 3A shows poorer performance in the normal water years type. Under Alternative 3A, spring Chinook performance may be slightly improved due to enhanced passage rates through the regulating outlet. However, downstream survival may be limited due to the need for construction modifications to the regulating outlet to make it safer for fish passage. This could limit success in the earlier years following implementation. It is expected that Alternative 3A would have MAJOR adverse impacts on spring Chinook in the McKenzie. Access to additional habitat is provided at Blue River Dam, using adult trap and haul for upstream passage and deep reservoir draw down in the fall for downstream fish passage. This combination of actions was successfully used at Fall Creek Dam to re-establish Chinook salmon, and would be expected to result in similar performance at Blue River Dam.

**Table 3.8-55. McKenzie Alternative 3A spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Fails | Fails | NA |
| IPA | Meets | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 3 | NA | 1 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Bull Trout**

The performance metrics for bull trout in the McKenzie under Alternative 3A are summarized in Table 3.8-56. Overall, habitat access may be increased but moderate demographic risk exists due to incomplete or potentially unsafe downstream passage conditions at Cougar, however it is uncertain if the rate of downstream fish passage, but with changes in RO use downstream passage would only somewhat increase when compared to the NAA. Since the population has been stable under operations similar to those assumed for the NAA, it is expected that Alternative 3A would have MODERATE impacts on bull trout in the McKenzie.

**Table 3.8-56. Summary of bull trout habitat scoring and relative risk under Alternative 3A in the McKenzie**

| Sub-basin | Region | Score | Demographic Risk |
|---|---|---|---|
| McKenzie | Above Cougar (rearing/foraging and spawning) | 11.95 | Moderate |
| | Below Cougar (rearing/foraging only) | 10.83 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

### *3.8.2.7.4 Middle Fork*

Under Alternative 3A, the existing adult facility at Fall Creek Dam will be used to collect and truck Chinook upstream of this dam. Downstream passage at Fall Creek Dam would be by a combination of operational downstream passage by way of a fall reservoir deep drawdown and a spring spill. It is uncertain if the addition of a spring spill will result in an increase or decrease in adult returns since there will be a change from larger smolts emigrating in fall, to a combination of fry in spring and smolts in fall passed downstream. A deeper fall reservoir drawdown (#40) and spring spill would be implemented at Lookout Point to facilitate passage. A deeper fall reservoir drawdown (#40) and spring reservoir drawdown (#720) would be implemented at Hills Creek to facilitate downstream passage, and a new adult fish facility built at the base of Hills Creek Dam to collect and truck Chinook and bull trout upstream of the dam.

## Chinook

The performance metrics for spring Chinook salmon in the Middle Fork under Alternative 3A are summarized in Table 3.8-57. The life cycle models mostly agree with respect to viability. Performance is predicted to be very poor under operational passage strategies, in particular for Lookout Point. It is unclear whether additional operations at Fall Creek would improve performance there since this population is already considered healthy under the NAA, and passage analysis was not considered in the weighting of this alternative. The EDT output reflects low resilience across water year types. Deep drafts at Lookout and Hills Creek will further limit the ability to control temperatures operationally which will likely further contribute to the lack of productivity and high prespawn mortality below Dexter. Although Hills Creek may be drawn upon to refill Lookout Point to support spring spill, refill probability is uncertain and the ability to conduct spring spill in every year is unlikely, particularly if the elevation at Lookout Point is still low following the fall draft. This could lead to juvenile oversummering and higher prespawn mortality. It is expected that Alternative 3A would have MAJOR adverse impacts to spring Chinook salmon in the Middle Fork.

**Table 3.8-57. Middle Fork Alternative 3A spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Meets | Fails | NA |
| IPA | Fails | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 3 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

## Bull Trout

The performance metrics for bull trout in the Middle Fork under Alternative 3A are summarized in Table 3.8-58. While habitat is available above and below Hills Creek, there is uncertainty in the effectiveness of operational downstream passage and therefore the effects on connectivity and production for the spawning population above Hills Creek. It is expected that Alternative 3A would have MAJOR adverse impacts on bull trout in the Middle Fork, primarily due uncertainty in downstream passage survival and return rates. For bull trout moving downstream which then migrate back up to Hills Creek Dam, an adult facility will allow for their collection and transport above Hills Creek Dam to re-enter the spawning population.

**Table 3.8-58. Summary of bull trout habitat scoring and relative risk under Alternative 3A in the Middle Fork**

| Sub-basin | Region | Score | Demographic Risk |
|---|---|---|---|
| Middle Fork | Above Hills Creek (rearing/foraging and spawning) | 9.3 | High |
| | Below Hills Creek (rearing/foraging only) | 10.12 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

##### *3.8.2.7.5 Near-term Operations Measure for Alternatives 2A, 2B, 3A, 3B, 4, 5*

See Alternative 2A, Section 3.10.2.4.5, for description of effects due to the Near-Term Operations Measure.

### ***3.8.2.8 Alternative 3B***

#### *3.8.2.8.1 North Santiam*

Under Alternative 3B, a deeper fall reservoir drawdown (#40) and spring spill would be implemented to facilitate passage at Detroit.

**Chinook**

The performance metrics for spring Chinook salmon in the North Santiam under Alternative 3B are summarized in Table 3.8-59. The life cycle model outputs are similar to results for Alternative 3A. The LCM predicts an inviable population with respect to quasi-extinction risk while the IPA predicts viability across all dimensions. Fish Benefits Workbook predicts that drawdowns at Detroit for downstream passage would be expected to provide some benefit. However, other measures may be more effective. The EDT output shows some resiliency with respect to diversity but not with respect to equilibrium abundance or recruits per spawner. This may reflect the availability of water to operate the alternative as intended in all year types. The effects on spring Chinook salmon would be similar to those described in 3A. It is expected that Alternative 3B would have MODERATE adverse impacts on spring Chinook salmon.

**Table 3.8-59. North Santiam Alternative 3B spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Fails | Fails | NA |
| IPA | Meets | Meets | Meets | NA |
| EDT Wet | 1 | 2 | NA | 1 |
| EDT Dry | 3 | 1 | NA | 2 |
| EDT Normal | 2 | 3 | NA | 1 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Steelhead**

The performance metrics for winter steelhead in the North Santiam under Alternative 3B are summarized in Table 3.8-60. The life cycle models disagree on viability in all dimensions. However, among alternatives 3A and 3B, the outputs were near the thresholds for viability. Slight changes in hydrology are likely responsible for the discrepancies between the outcomes for alternatives 3A and 3B. This is also reflected in the EDT output that show resiliency in the diversity metric for wet and normal years and slightly worse performance in dry years since water availability may be more limiting. The effects on winter steelhead would be similar to those described in Alternative 3A. It is expected that Alternative 3B would have MODERATE adverse impacts on winter steelhead in the North Santiam.

**Table 3.8-60. North Santiam Alternative 3B winter steelhead performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Meets | Meets | NA |
| IPA | Fails | Fails | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Bull Trout**

The performance metrics for bull trout under Alternative 3B in the North Santiam are summarized in Table 3.8-61. There would be adequate habitat available for bull trout above and below Detroit. However, the limited and potentially unsafe passage conditions at Detroit under Alternative 3B for bull trout could put the population at higher demographic risks if those fish attempting to move downstream were unable to return to the parent population to contribute to productivity. It is expected that Alternative 3B would have MODERATE adverse impacts on bull trout in the North Santiam.

**Table 3.8-61. Summary of bull trout habitat scoring and relative risk under Alternative 3B in the North Santiam**

| Sub-basin | Region | Score | Demographic Risk |
|---|---|---|---|
| North Santiam | Above Detroit (rearing/foraging and spawning) | 41.49 | High |
| | Below Detroit (rearing/foraging only) | 28.4 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

### *3.8.2.8.2 South Santiam*

Under Alternative 3B, a spring spill would continue to be implemented at Foster and a spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40) would be implemented to facilitate passage at Green Peter. A deeper fall reservoir drawdown (#40) and spring spill would be implemented for downstream passage at Green Peter. Upstream passage at Foster Dam would utilize the existing fish facility. An adult fish facility would also be constructed at the base of Green Peter Dam. These fish passage improvements allow Chinook and steelhead to access habitat above both Foster and Green Peter dams, supporting the potential for increased abundance and productivity compared to the NAA. Compared to above other WVS dams, the relatively lower elevation habitat above these dams may constrain productivity and survival.

**Chinook**

The performance metrics for spring Chinook salmon in the South Santiam under Alternative 3B are summarized in Table 3.8-62. Neither life cycle model predicts viability in all dimensions and it is expected performance would be similar to that predicted for Alternative 3A. The South Santiam is a two dam system where wild fish sanctuary is only designated above one of the two dams (Foster). There is uncertainty about how successful reintroduction above Green Peter would be given the proposed operational passage at both projects. While available data suggest that operational passage could be successful at Foster Dam, there is more uncertainty in operational downstream passage at Green Peter Dam given limited data. It is also possible that the higher number of hatchery outplants (800) assumed at Green Peter relative to other projects, directly affects productivity of wild fish, since fitness differences between the two groups are assumed in both life cycle models. The EDT output indicate some resiliency with respect to recruits per spawner, equilibrium spawner abundance and diversity are subject to the availability of water which would be limited under Alternative 3B. It is expected that Alternative 3B would have MAJOR adverse impacts on spring Chinook salmon in the South Santiam.

**Table 3.8-62. South Santiam Alternative 3B spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | See 3a | See 3a | See 3a | NA |
| IPA | Meets | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 3 | NA | 3 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Steelhead**

The performance metrics for winter steelhead in the South Santiam under Alternative 3B are summarized in Table 3.8-63. In general, the life cycle models are in agreement regarding viability in the South Santiam under Alternative 3B. Steelhead may respond less well to operational passage at Green Peter. The EDT outputs indicate a similar pattern of resiliency for Chinook. The effects on winter steelhead are similar to those described for Chinook. It is expected that Alternative 3B would have MAJOR adverse impacts on winter steelhead in the South Santiam.

**Table 3.8-63. South Santiam Alternative 3B winter steelhead performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Meets | Fails | NA |
| IPA | Fails | Fails | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

#### *3.8.2.8.3 McKenzie*

Under Alternative 3B, a drawdown to the diversion tunnel would facilitate downstream fish passage at Cougar for Chinook and bull trout. The existing adult fish facility would be used to truck collected fish upstream of Cougar Dam. A deeper fall reservoir drawdown (#40) would be implemented for downstream passage at Blue River and a new adult fish facility (#722) would be constructed to collect returning adults.

## Chinook

The performance metrics for spring Chinook salmon in the McKenzie under Alternative 3B are summarized in Table 3.8-64. The IPA predicts viability in all dimensions. Recall that the LCM considers natural origin spawners below Cougar as well as above and downstream impacts from operational effects upstream of the population. There may be uncertainty around the efficiency of using the diversion tunnel at Cougar for downstream juvenile passage given that this operation lacks a robust data set to inform. Similar to other alternatives, the EDT output shows resiliency in the diversity metric likely due to the broader spectrum of life histories observed to outmigrate from the McKenzie sub-basin. A drawdown to the diversion tunnel at Cougar Dam would have similar effects to those described under Alternative 2B. Access to additional habitat is provided at Blue River Dam, using adult trap and haul for upstream passage and deep reservoir draw down in the fall for downstream fish passage. This combination of actions was successfully used at Fall Creek Dam to re-establish Chinook salmon, and would be expected to result in similar performance at Blue River Dam. It is expected that Alternative 3B would have MODERATE adverse impacts on spring Chinook salmon in the McKenzie.

**Table 3.8-64. McKenzie Alternative 3B spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Fails | Fails | NA |
| IPA | Meets | Meets | Meets | NA |
| EDT Wet | 1 | 1 | NA | 2 |
| EDT Dry | 3 | 3 | NA | 1 |
| EDT Normal | 2 | 2 | NA | 1 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

## Bull Trout

The performance metrics for bull trout in the McKenzie under Alternative 3B are summarized in Table 3.8-65. In general, there are good habitat opportunities above and below Cougar. However, the uncertainty about the effectiveness of passage through the diversion tunnel poses high demographic risk if bull trout are not able to return to their natal upstream reach to spawn. Cougar Reservoir will largely be drained in spring and only partially refilled in summer due to summer inflow, resulting in significant reduction in rearing/foraging opportunity within the reservoir. Many bull trout would be expected to move upstream into the South Fork McKenzie, or below Cougar Dam to rear. Suitable habitat for bull trout exists above and below Cougar Dam and Reservoir, however carry capacity and other effects of redistribution on survival and spawning is uncertain. It is expected that Alternative 3B would have MODERATE adverse impacts on bull trout in the McKenzie.

**Table 3.8-65. Summary of bull trout habitat scoring and relative risk under Alternative 3B in the McKenzie**

| Sub-basin | Region | Score | Demographic Risk |
|---|---|---|---|
| McKenzie | Above Cougar (rearing/foraging and spawning) | 12.07 | High |
| | Below Cougar (rearing/foraging only) | 10.95 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

### *3.8.2.8.4 Middle Fork*

Under Alternative 3B, the existing adult facility at Fall Creek Dam in combination with the operational downstream passage by way of a fall reservoir deep drawdown will support maintaining the re-established Chinook sub-population above Fall Creek Dam. A deeper fall reservoir drawdown (#40) and spring spill would be implemented at Lookout Point to facilitate passage. At Hills Creek Dam, a spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40) would be implemented for downstream passage. Upstream passage would include use of the existing adult fish facility at Dexter for Chinook and construction of a new adult fish facility at the base of Hills Creek Dam for Chinook and bull trout.

**Chinook**

The performance metrics for spring Chinook salmon in the Middle Fork under Alternative 3B are summarized in Table 3.8-66. The IPA demonstrates poor performance with respect to equilibrium spawner abundance and quasi-extinction risk. Recruits per spawner indicates viability but the numerical outputs show that this value is nearly non-viable. The EDT output show patterns similar to other alternatives in that Alternative 3B is not resilient to hydrology year type. This is likely due to temperature limitations in the Middle Fork and the inability to adequately manage temperatures using operations. The effects on spring Chinook would be similar to those described under Alternative 3A. It is expected that Alternative 3B would have MAJOR adverse impacts on spring Chinook salmon in the Middle Fork.

**Table 3.8-66. Middle Fork Alternative 3B spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Meets | Fails | NA |
| IPA | Fails | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 3 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Bull Trout**

The performance metrics for bull trout in the Middle Fork under Alternative 3B are summarized in Table 3.8-67. While habitat is available above and below Hills Creek, there is uncertainty in the effectiveness of operational downstream passage and therefore the effects on connectivity and production for the spawning population above Hills Creek. It is expected that Alternative 3A would have MAJOR adverse impacts on bull trout in the Middle Fork, primarily due uncertainty in downstream passage survival and return rates. For bull trout moving downstream which then migrate back up to Hills Creek Dam, an adult facility will allow for their collection and transport above Hills Creek Dam to re-enter the spawning population.

**Table 3.8-67. Summary of bull trout habitat scoring and relative risk under Alternative 3B in the Middle Fork**

| Sub-basin | Region | Score | Demographic Risk |
|---|---|---|---|
| Middle Fork | Above Hills Creek (rearing/foraging and spawning) | 10.09 | High |
| | Below Hills Creek (rearing/foraging only) | 10.3 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

##### *3.8.2.8.5 Near-term Operations Measure for Alternatives 2A, 2B, 3A, 3B, 4, 5*

See Alternative 2A, Section 3.10.2.4.5, for description of effects due to the Near-Term Operations Measure.

### *3.8.2.9 Alternative 4*

#### *3.8.2.9.1 North Santiam*

Under Alternative 4, a structural collector (measure #392) would be implemented to facilitate downstream passage at Detroit. Upstream migrating fish would be collected at Minto adult fish facility and trucked above Detroit Dam.

**Chinook**

The performance metrics for spring Chinook salmon in the North Santiam under Alternative 4 are summarized in Table 3.8-68. Alternative 4 proposes a structural passage solution at Detroit. In general, both models predict viability. This is consistent with the prior patterns demonstrated for structural downstream passage and overall performance of populations in the North Santiam for most Action Alternatives. The EDT outputs show some resiliency with respect to diversity but not with respect to equilibrium spawner abundance or recruit per spawner. This is a surprising result given that the passage structure is able to operate in most types of hydrology. This result could reflect the consideration of below dam components that also contribute to the metrics. Effects on spring Chinook salmon under Alternative 4 would be functionally similar to those described in Alternative 2B. It is expected that Alternative 4 would have MINOR adverse impacts on spring Chinook salmon in the North Santiam.

**Table 3.8-68. North Santiam Alternative 4 spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Meets | Meets | NA |
| IPA | Meets | Meets | Meets | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 2 |
| EDT Normal | 2 | 3 | NA | 1 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Steelhead**

The performance metrics for winter steelhead in the North Santiam under Alternative 4 are summarized in Table 3.8-69. The life cycle models predict high steelhead performance with the implementation of a structure at Detroit. Both models predict reasonable performance; however, the IPA predicts somewhat higher quasi-extinction risk than the LCM. The EDT outputs indicate resiliency with respect to recruit per spawner but not with respect to equilibrium spawner abundance and diversity. Effects on winter steelhead under Alternative 4 would be functionally similar to those described under Alternative 2B. It is expected that Alternative 4 would have MINOR adverse impacts to winter steelhead.

**Table 3.8-69. North Santiam Alternative 4 winter steelhead performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Meets | Meets | NA |
| IPA | Meets | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Bull Trout**

The performance metrics for bull trout in the North Santiam under Alternative 4 are summarized in Table 3.8-70. It is expected that high quality habitat would be available above and below Detroit dam. However, since there is no spawning habitat below Detroit Dam, the effectiveness would be dependent upon the ability of bull trout to survive while in habitat downstream of Detroit and Big Cliff dams, and then be collected and trucked back up to their natal streams above Detroit and spawn. It is expected that Alternative 4 would have MODERATE adverse impacts on bull trout in the North Santiam.

**Table 3.8-70. Summary of bull trout habitat scoring and relative risk under Alternative 4 in the North Santiam**

| Sub-basin | Region | Score | Demographic Risk |
|---|---|---|---|
| North Santiam | Above Detroit (rearing/foraging and spawning) | 41.69 | High |
| | Below Detroit (rearing/foraging only) | 37.79 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

*3.8.2.9.2 South Santiam*

Under Alternative 4, downstream passage at Foster Dam would be provided by a dedicated fish pipe or weir (measure #392). Upstream fish passage at Foster Dam would occur using the existing adult fish facility. No fish passage would be implemented at Green Peter Dam.

**Chinook**

The performance metrics for spring Chinook salmon in the South Santiam under Alternative 4 are summarized in Table 3.8-71. Although the LCM is more optimistic than the IPA, both ultimately predict non-viable populations. This may reflect the fact that passage at Green Peter is not included under Alternative 4. The EDT output shows resiliency with respect to equilibrium spawner abundance and recruit per spawner but not diversity. This may reflect that fact that there is no population unit above Green Peter and fish above Foster only leave the system through a dedicated fish pipe or weir in the spring or summer at larger size. Under Alternative 4, structural downstream passage does not result in viable populations. This could be due to a lack of adequate temperature control in the adult fish ladder or low assumed intrinsic productivity. It is expected that Alternative 4 would have MAJOR adverse impacts on spring Chinook salmon in the South Santiam.

**Table 3.8-71. South Santiam Alternative 4 spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | See 2A | See 2A | See 2A | NA |
| IPA | Fails | Fails | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 2 | 2 | NA | 3 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Steelhead**

The performance metrics for winter steelhead in the South Santiam under Alternative 4 are summarized in Table 3.8-72. The life cycle models do not agree in all dimensions. The LCM does not predict viability with respect to quasi-extinction risk while the IPA predicts poor performance with respect to spawner abundance and quasi-extinction risk. This may reflect differences in sensitivity between the two models to structural versus operational downstream passage. The EDT outputs indicate some resiliency with respect to recruits per spawner. Unlike spring Chinook, one model predicts viability across performance dimensions. This could be to the assumed higher resiliency of winter steelhead compared to Chinook, the flexibility of reservoir types to adopt anadromy under effective passage conditions, or the ability of kelts to safely pass downstream. It is expected that Alternative 4 would have MINOR adverse impacts on winter steelhead in the South Santiam.

**Table 3.8-72. South Santiam Alternative 4 winter steelhead performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Meets | Fails | NA |
| IPA | Fails | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 2 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

### *3.8.2.9.3 McKenzie*

Under Alternative 4, a structural collector would be implemented at Cougar for downstream passage. The existing adult fish facility at the base of Cougar Dam would be used for upstream fish passage.

## Chinook

The performance metrics for spring Chinook salmon in the McKenzie under Alternative 4 are summarized in Table 3.8-73. Passage is indicated at Cougar and both life cycle models indicate Poor performance in both models. The EDT outputs indicate resiliency with respect to diversity, as in previous alternatives, due to the broader spectrum of life history strategies observed to outmigrate from the McKenzie. The effects on spring Chinook salmon under Alternative 4 are functionally similar to those described under Alternative 2A. It is expected that Alternative 4 would have MODERATE impacts on spring Chinook salmon in the McKenzie.

**Table 3.8-73. McKenzie Alternative 4 spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Fails | Meets | NA |
| IPA | Fails | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 3 | NA | 1 |
| EDT Normal | 2 | 2 | NA | 1 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

## Bull Trout

The performance metrics for bull trout in the McKenzie under Alternative 4 are summarized in Table 3.8-74. In general, Alternative 4 provides good bull trout habitat above and below Cougar Dam and only poses a moderate demographic risk relating to the uncertainty in downstream passage and survival rates of bull trout that move below the dam. Safe downstream passage is assumed for those bull trout collected in the at-dam passage structure, and safe upstream passage for those collected at the adult facility downstream, then transported above Cougar to contribute to population productivity. Under this alternative, the reservoir is maintained providing forage habitat for bull trout. It is expected that Alternative 4 would have MODERATE adverse impacts on bull trout in the McKenzie.

**Table 3.8-74. Summary of bull trout habitat scoring and relative risk under Alternative 4 in the McKenzie**

| Sub-basin | Region | Score | Demographic Risk |
|---|---|---|---|
| McKenzie | Above Cougar (rearing/foraging and spawning) | 11.86 | Moderate |
| | Below Cougar (rearing/foraging only) | 14.27 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

### *3.8.2.9.4 Middle Fork*

Under Alternative 4, the existing adult facility at Fall Creek Dam in combination with the operational downstream passage by way of a fall reservoir deep drawdown will support maintaining the re-established Chinook sub-population above Fall Creek Dam. The construction of structural downstream fish passages (#392) would be implemented at Lookout Point and Hills Creek dams. Adults would be passed from the base of Dexter Dam above Lookout Point Reservoir using the existing adult facility. A second adult fish facility would be used to collected and transport adult Chinook and bull trout upstream of Hills Creek Dam.

**Chinook**

The performance metrics for spring Chinook salmon in the Middle Fork under Alternative 4 are summarized in Table 3.8-75. Recall that the LCM is not calibrated to natural origin spawners in the Middle Fork so output represent a relative comparison across alternatives. For this reason, the IPA was relied upon in the Middle Fork. Chinook performance in Alternative 4 is similar to that of Alternative 2A: the model demonstrates viability with respect to equilibrium spawner abundance and recruit per spawner but not with respect to quasi-extinction risk. In fact, Alternative 4 predicted the second lowest extinction risk in the Middle Fork (65%). Under Alternative 2A, extinction risk was only marginally improved. These results indicate that no alternative produced a viable population in the Middle Fork. This is likely due to the low elevation in the sub-basin, the limiting temperatures, and high observed pre-spawn mortality (sometimes up to 100%). The EDT outputs are similar to 2A, which also proposes an at-dam structure for downstream passage. Under Alternative 4, effective passage would result in higher downstream passage rates with some ability to control downstream temperatures using a structural temperature control tower. However, the ability to fully address high temperatures in the Middle Fork is limited and current rates of prespawn mortality are likely to continue limiting this population. It is expected that Alternative 4 would have MAJOR adverse impacts on spring Chinook salmon in the Middle Fork.

**Table 3.8-75. Middle Fork Alternative 4 spring Chinook salmon performance across each model**

| Model | Spawner Abundance | Recruit per Spawner | Quasi-extinction Risk | Diversity |
|---|---|---|---|---|
| LCM | Meets | Meets | Fails | NA |
| IPA | Meets | Meets | Fails | NA |
| EDT Wet | 1 | 1 | NA | 1 |
| EDT Dry | 3 | 2 | NA | 3 |
| EDT Normal | 2 | 3 | NA | 2 |

Note: as indicated by viability rating (viable, nearly viable, not viable). EDT outputs are ranked according to performance across year type.

**Bull Trout**

The performance metrics for bull trout in the Middle Fork under Alternative 4 are summarized in Table 3.8-76. Alternative 4 provides good bull trout good habitat access above and below Hills Creek Dam however poses a high demographic risk relating to the uncertainty in downstream passage and survival rates of bull trout that move below the dam. Safe downstream passage is assumed for those bull trout collected in the at-dam passage structure, and safe upstream passage for those collected at the adult facility downstream, then transported above Hills Creek Dam to contribute to population productivity. It is expected that Alternative 4 would have MODERATE adverse impacts on bull trout in the Middle Fork.

**Table 3.8-76. Summary of bull trout habitat scoring and relative risk under Alternative 4 in the Middle Fork**

| Sub-basin | Region | Score | Demographic Risk |
|---|---|---|---|
| Middle Fork | Above Hills Creek (rearing/foraging and spawning) | 10.03 | High |
| | Below Hills Creek (rearing/foraging only) | 13.48 | |

Note: given fisheries, predation, temperature, and connectivity. Scores are indicated by region above or below project.

*3.8.2.9.5 Near-term Operations Measure for Alternatives 2A, 2B, 3A, 3B, 4, 5*

See Alternative 2A, Section 3.10.2.4.5, for description of effects due to the Near-Term Operations Measure.

***3.8.2.10 Alternative 5***

Alternative 5 is functionally similar Alternative 2B except that there is slightly more water released from the Santiam in the spring of dry years. Non-exceedance plots were compared for alternatives 2B and 5 (see Appendix B). Based on this assessment, it was determined that the flow management differences between alternatives 2B and 5 would be insignificant with respect to fish performance.

### 3.8.3 Climate Change

Crozier et al. (2019) (herein Crozier) conducted a comprehensive climate vulnerability assessment for Pacific salmon and steelhead (*Oncorhynchus* spp.) for distinct population segments (DPSs) in the U.S. They followed the climate vulnerability assessment method developed by Hare et al. (2016), which is now being implemented for U.S. marine and anadromous species by NOAA Fisheries (Link et al. 2015). The Crozier assessment was based on three components of vulnerability (i.e. relative threats) to climate change for each DPS: 1) biological sensitivity, which is a function of individual species characteristics; 2) climate exposure, which is a function of geographical location and projected future climate conditions; and 3) adaptive capacity, which describes the ability of a DPS to adapt to rapidly changing environmental conditions. Crozier found that in general, DPSs with the highest sensitivity and exposure and lowest adaptive capacity were the most vulnerable to climate change.

Access to high elevation habitat to reduce effects of climate change has been found important by others (Myers et al. 2018; Fitzgerald et al. 2021). Myers et al. (2018) summarized that climate change is expected to reduce UWR Chinook adult abundance and increase the risk of extinction in the North Santiam River, South Santiam River, McKenzie River, and Middle Fork Willamette River. Compared to UWR Chinook, Upper Willamette River winter steelhead (UWR steelhead) were found to have a high overall vulnerability, high biological sensitivity, high climate exposure and moderate adaptive capacity.

**Table 3.8-77. Climate change vulnerability assessment results from Crozier et al. (2019) for UWR Chinook and UWR steelhead.**

| | UWR Chinook | UWR steelhead |
|---|---|---|
| Overall vulnerability | Very high | High |
| Biological sensitivity | Very high | High |
| Climate exposure | High | High |
| Adaptive capacity | Moderate | Moderate |

Since vulnerability was assessed as higher for UWR Chinook than for UWR steelhead, we focused our assessment of climate change for the WVS EIS on this species and assumed results from this approach would be somewhat conservative for considering effects for UWR steelhead. We further assumed the scoring for spring Chinook would be relatively similar for bull trout, although somewhat underestimated for bull trout due to their greater dependence on cold water (Reiman and McIntyre 1995). Finally, since Alternatives 2B and 5 are comprised of the same measures (only differing in minimum flow targets), and hydrologic modeling showed very little to no differences in resulting reservoir and downstream river flows, these two alternatives were treated as equivalent for purposes of this assessment.

Using the attribute definitions from Crozier, we assumed the following specific attributes would not differ among EIS alternatives, and therefore applied results for these from Crozier et al. 2019:

- ocean acidification
- sea surface temperature
- hydrologic regime
- cumulative life-cycle effects
- adaptive capacity

#### *3.8.3.1 Stream Temperatures*

Bond et al. 2016 estimated changes in redd capacity for UWR Chinook populations affected by WVS dams in future water temperature scenarios. Water temperature effects below dams are accounted for in extinction risk estimates from life cycle models applied for assessing population viability. Criteria for categorizing the vulnerability of UWR Chinook to stream temperatures based on the percentage of spawning habitat available in each WVS EIS alternative under future climate change scenarios:

**Table 3.8-78.**

| | Percent of accessible future Chinook spawning habitat above WVS dams | | | |
|---|---|---|---|---|
| | <25% | 25-49% | 50-74% | >=75% |
| Vulnerability criteria | Very High | High | Moderate | Low |

#### *3.8.3.2 Summer Water Deficit*

Crozier used the evapotranspiration differential (potential minus actual), also known as the summer water deficit. For above dam reaches, we applied a moderate categorization for summer water deficit for all sub-basins (see Appendix X). For below dam reaches, reservoirs have an important effect on summer flows and therefore we applied a qualitative assessment of reservoir storage availability with future climate change as a proxy for stream flow below dams (see WVS EIS Appendix B).

When developing this approach, we also considered including changes in summer temperatures, and the availability of High Cascade base flows, in the Santiam, McKenzie and Middle Fork Willamette sub-basins. There was little difference in the estimated change in summer temperatures between subbasins (Appendix F1 Summary and Conclusions, Appendix F2 3.2.3, Figures 11-54). Redd capacities changed very little in the North Santiam and McKenzie above WVS dams under future climate change temperature scenarios (Bond et al. 2017; see Additional Information Section below), and so we assumed the resiliency to summer water deficit, due to the greater contribution of High Cascade base flow in these sub-basins, is reasonably reflected in the assessment under the attributes where redd capacities are applied.

#### *3.8.3.3 Adult Freshwater Stage*

The adult freshwater stage attribute as assessed by Crozier considered stressors encountered during upstream migration, holding and spawning. Considerations included migration distance and duration and climate stressors encountered including temperature and flow constraints. Resiliency (i.e. the ability to anticipate, prepare for, and adapt to changing conditions) for fish passage and temperature management at dams, for purposes of this assessment was considered in terms of operational flexibility. Downstream fish passage resiliency of each alternative was assessed based on the type of downstream fish passage operations included (specifically the number of spring deep drawdowns) and the number of downstream fish passage structures included in each alternative.

**Table 3.8-79. Criteria applied to assess the resiliency of downstream fish passage (DSP) at dams to climate change.**

| | Vulnerability | | |
|---|---|---|---|
| | **Very High to High** | **Moderate** | **Low** |
| Resiliency | Very Low to Low | Moderate | High |
| Flexibility in DSP ops | spring deep drawdowns at 1 or fewer dams | spring deep drawdowns at 2-3 dams | spring deep drawdowns at 4-5 or more dams |
| # of DSP structures | 0-1 dams | 2-2.5 dams | 3 or more dams |

### *3.8.3.4 Population Viability*

For a low viability criteria, we assumed 3 populations need to be at low extinction risk. This is a conservative application of the UWR 2011 Recovery Plan delisting criteria.

Criteria for categorizing the vulnerability of UWR Chinook viability based on the number of populations affected by the WVS at low risk of extinction in each WVS EIS alternative(Table 3.8-80).

**Table 3.8-80.**

| | Number of WVS-effected populations with low risk of extinction | | | |
|---|---|---|---|---|
| | **3** | **2** | **1** | **0** |
| Vulnerability criteria | Low | Moderate | High | Very High |

### *3.8.3.5 Hatchery influence*

The same scores applied for population viability were applied for hatchery influence.

### *3.8.3.6 Other stressors*

We assessed the change in "other stressor" attributes highlighted by Crozier for UWR Chinook.

### *3.8.3.7 Results*

The cumulative vulnerability of UWR Chinook was rated as high to very high across the WVS EIS alternatives (Table 3.8-81 and 3.8-82). These high and very high ratings reflect high vulnerability scores for ocean acidification, seas surface temperature, hydrologic regime and cumulative life-cycle effects, as determined by Crozier et al. 2019 for UWR Chinook. Alternatives 2A and 4 received the lowest cumulative vulnerability scores (10.0). These results were driven by better (lower) scores for population viability and hatchery influence as compared to the other alternatives. Alternative 3A and 3B had the highest vulnerability scores (16.0). Vulnerability scores for 3A and 3B reflect the poor results for summer water deficit below dams, population viability and hatchery influence attributes. Alternative 2B scored intermediate among the alternatives.

Depending on how climate change impacts hydrology and temperatures above and below WVS dams in each sub-basin specifically, implementing more structural measures similar to those included in Alternatives 2A or 4 may be necessary to avoid unacceptable effects from climate change in the future, where resiliency of operational measures is found insufficient. However, if additional measures need to be considered in the future, it will be important to review the performance of downstream structural fish passage measures in particular before they are employed at additional dams, given the uncertainty in their ability to improve passage rates and survival of Chinook salmon more so than operational measures at high head dams with large fluctuating forebays (see Section 3.10.3.1 Estimation of Uncertainty; Kock et al. 2019).

**Table 3.8-81. Attribute categorization results for assessment of climate vulnerability of Upper Willamette spring Chinook salmon. Results for the NAA and attributes marked with a (1) are adopted from Crozier et al. 2019.**

| Attribute | NAA[1] | Alt1 | Alt2A | Alt2B/Alt 5 | Alt3A | Alt3B | Alt4 |
|---|---|---|---|---|---|---|---|
| **Exposure Attributes** | | | | | | | |
| ocean acidification[1] | Very high | Very high | Very high | Very high | Very high | Very high | Very high |
| stream temperature | Very High | Moderate | Low | Low | Low | Low | Low |
| sea surface temperature[1] | High | High | High | High | High | High | High |
| hydrologic regime[1] | High | High | High | High | High | High | High |
| summer water deficit above dams[1] | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate |
| summer water deficit below dams | Moderate | Moderate | Moderate | Moderate | High | High | Moderate |
| **Sensitivity Attributes** | | | | | | | |
| adult freshwater stage | Very High | Moderate | Moderate | Moderate | High | High | Moderate |
| cumulative life-cycle effects[1] | Very High | Very High | Very High | Very High | Very High | Very High | Very High |
| population viability | Very High | Moderate | Low | Moderate | High | High | Low |
| hatchery influence | Very High | Moderate | Low | Moderate | High | High | Low |
| other stressors | High | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate |
| **Adaptive Capacity**[1] | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate |

**Table 3.8-82. Overall vulnerability results based on conversion of assessment categories to numeric scores. Results from Crozier et al. (2019) are applied for the NAA. Results for attributes noted with a superscript 1 are also from Crozier et al. (2019), assuming these attributes would not be changing under each WVS EIS alternative.**

| Attribute | NAA[1] | Alt1 | Alt2A | Alt2B/Alt 5 | Alt3A | Alt3B | Alt4 |
|---|---|---|---|---|---|---|---|
| Exposure Attributes | High | 2.7 | 2.5 | 2.5 | 2.7 | 2.7 | 2.5 |
| ocean acidification[1] | Very high | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| stream temperature | Very High | 2.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| sea surface temperature[1] | High | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| hydrologic regime[1] | High | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| summer water deficit above dams[1] | Moderate | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| summer water deficit below dams | Moderate | 2.0 | 2.0 | 2.0 | 3.0 | 3.0 | 2.0 |
| Sensitivity Attributes | Very High | 2.4 | 2.0 | 2.4 | 2.8 | 2.8 | 2.0 |
| adult freshwater stage | Very High | 2.0 | 2.0 | 2.0 | 3.0 | 3.0 | 2.0 |
| cumulative life-cycle effects[1] | Very High | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| population viability | Very High | 2.0 | 1.0 | 2.0 | 3.0 | 3.0 | 1.0 |
| hatchery influence | Very High | 2.0 | 1.0 | 2.0 | 3.0 | 3.0 | 1.0 |
| other stressors | High | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Adaptive Capacity[1] | Moderate | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Overall Vulnerability | Very High | 12.8 | 10.0 | 12.0 | 16.0 | 16.0 | 10.0 |
| | | Very High | High | Very High | Very High | Very High | High |

#### *3.8.3.8 Estimation of Uncertainty*

All models demonstrate considerable uncertainty among alternatives. This is most evident in tradeoff analyses between critical evaluation criteria. Such tradeoff analyses were available for the Integrated Passage Assessment. Given the sensitivity of spring Chinook relative to winter steelhead, spring Chinook were the focus of uncertainty analyses. Spring Chinook abundance was regressed against maximum recruits per spawner by alternative to demonstrate the considerable overlap in management strategy. Abundance informs the extinction risk so only abundance versus maximum recruits per spawner is given for each sub-basin below.

#### *3.8.3.9 North Santiam*

The tradeoff graphic for North Santiam Chinook salmon by alternative is given in Figure 3.8-16. Alternatives 2A, 2B, and 4 nearly completely overlap and demonstrate the broadest distribution of possible performance values; however, performance is overall better than 3A and 3B in most cases, and better than the NAA in all cases. The NAA demonstrated the smallest range of possible outcomes but also produced the worst performance.

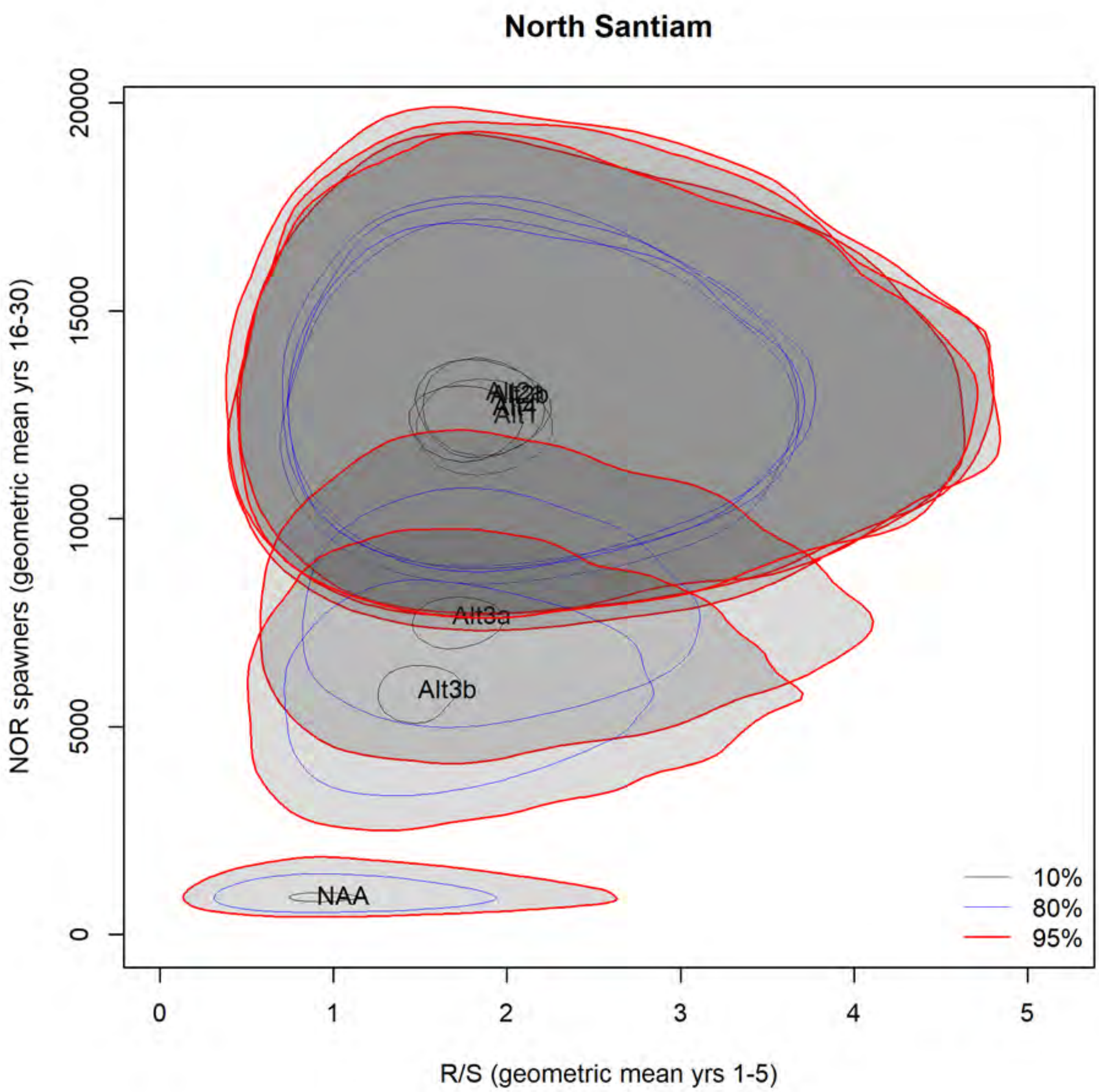



**Figure 3.8-16. Tradeoff plot for North Santiam Chinook salmon showing abundance regressed against maximum recruits per spawner. Alternatives are shown by bubbles and represent the range of possible values in each evaluation metric. Confidence bands are given by each color (10%, 80%, and 95% confidence).**

### *3.8.3.10 South Santiam*

The tradeoff graphic for South Santiam Chinook salmon by alternative is given in Figure 3.8-17. Alternatives show far more overlap in 95% confidence than in the North Santiam. In general, Alternative 1, 2A, and 2B performed best but they all overlap with 3A and 3B in some cases. The NAA demonstrated the smallest range of possible outcomes but also produced the worst performance and did not overlap with the performance of any of the action alternatives. In contrast to the North Santiam, Alternative 1 performed better in the South Santiam overall but still substantially overlapped the other top two performing alternatives, 2A and 2B. Alternative 4 completely overlaps the NAA performance. Alternative 4 includes structural passage at Green Peter but does not predict sustainability with respect to evaluation thresholds.

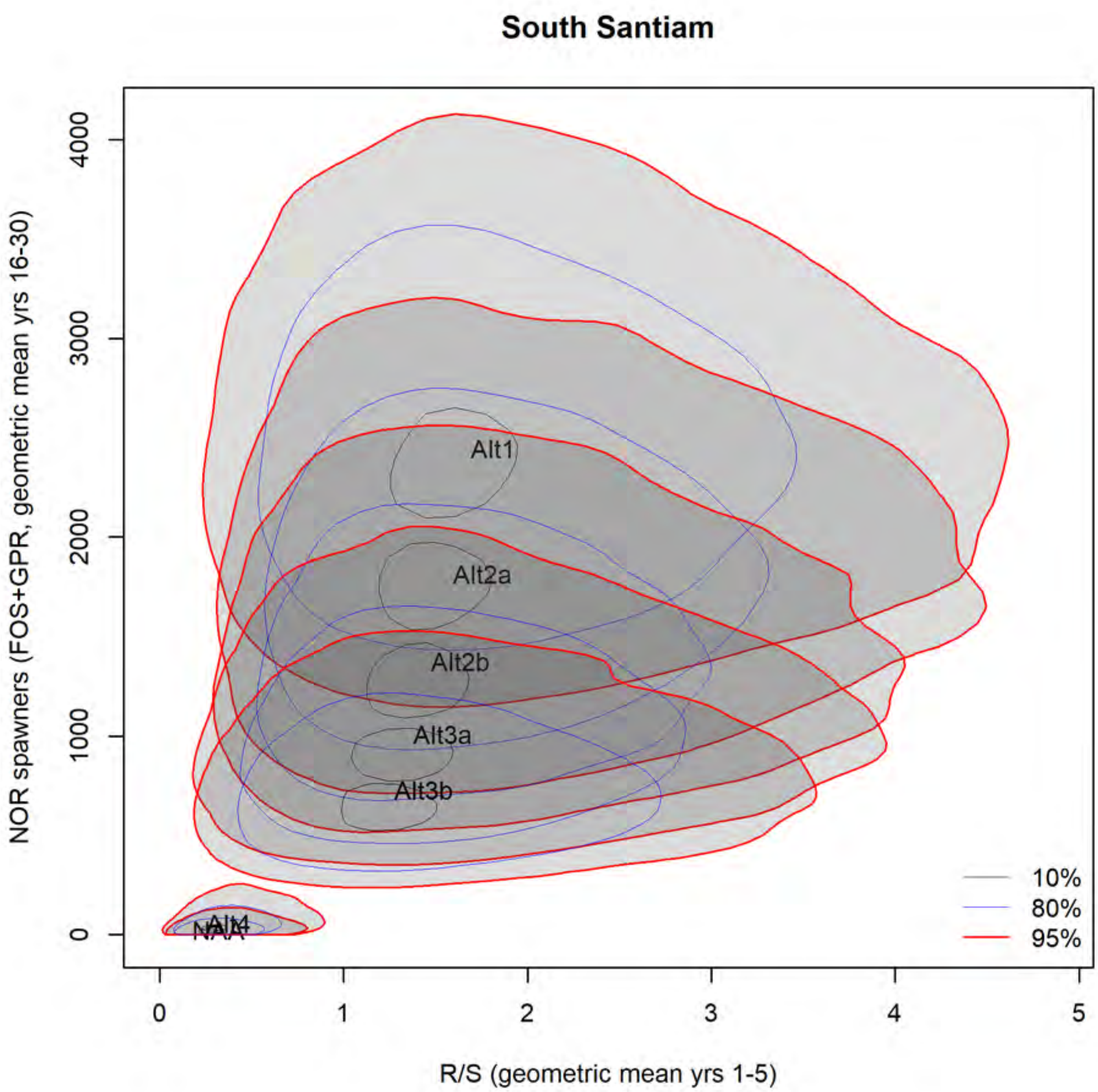



**Figure 3.8-17. Tradeoff plot for South Santiam Chinook salmon showing abundance regressed against maximum recruits per spawner. Alternatives are shown by bubbles and represent the range of possible values in each evaluation metric. Confidence bands are given by each color (10%, 80%, and 95% confidence).**

### *3.8.3.11 McKenzie*

The tradeoff graphic for McKenzie Chinook salmon by alternative is given in Figure 3.8-18. Alternatives demonstrated more discrete performance in 95% confidence intervals in the

McKenzie, than either the North and South Santiam. Alternatives 4 and 2A performed the best overall, though there is overlap with 2B in some cases. This is likely because alternatives 2A and 4 include structural passage at Cougar, while alternatives 2B, 3A, and 3B include operational passage. Alternatives 1, 3A, and 3B are compressed with respect to abundance, but can take on a wide range of recruit per spawner values, similar to alternatives 2B, 2A, and 4.

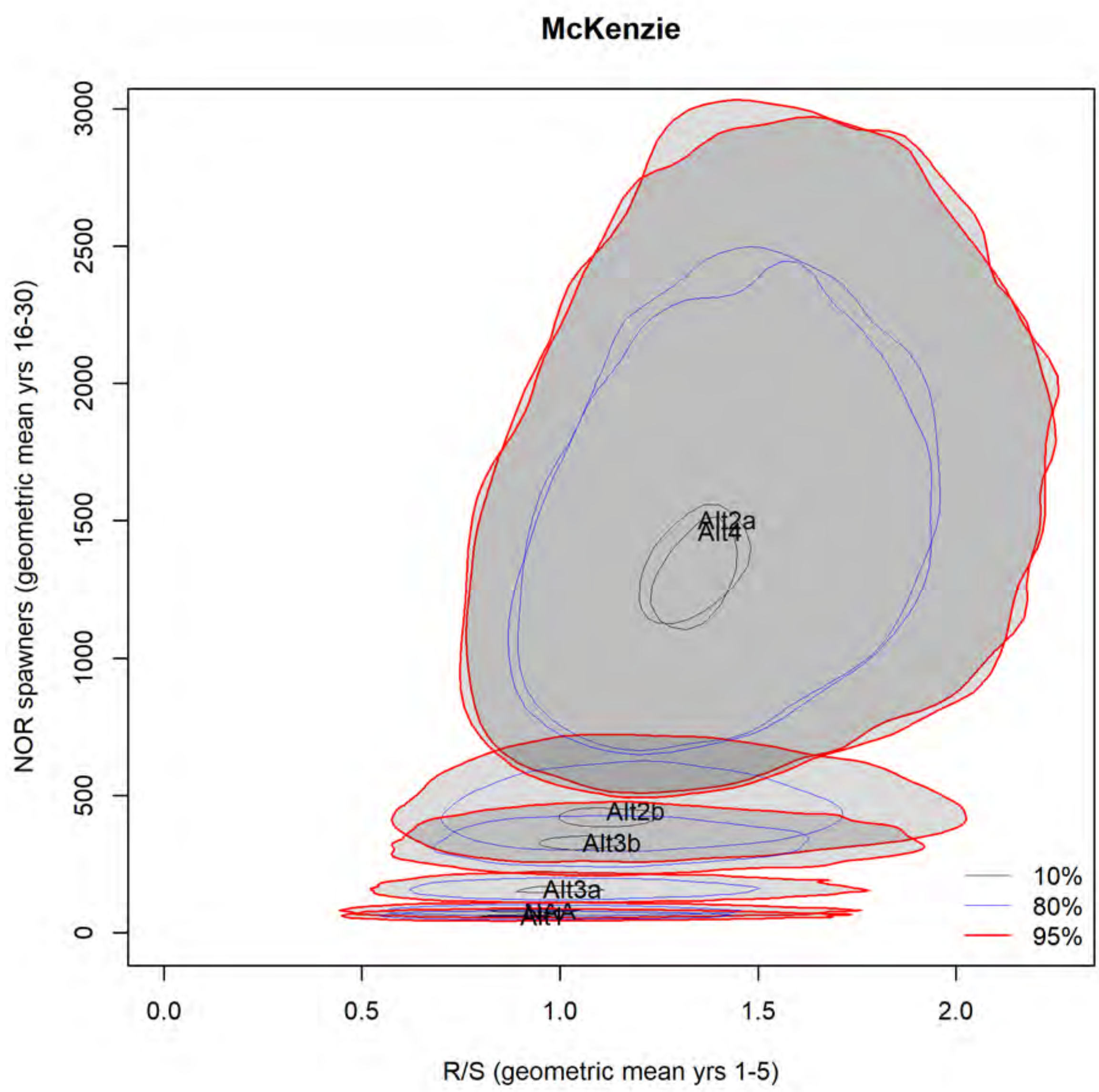



**Figure 3.8-18. Tradeoff plot for McKenzie Chinook salmon showing abundance regressed against maximum recruits per spawner. Alternatives are shown by bubbles and represent the range of possible values in each evaluation metric. Confidence bands are given by each color (10%, 80%, and 95% confidence).**

### *3.8.3.12 Middle Fork*

The tradeoff plot for the Middle Fork is given by Figure 3.8-19. Alternative 4 demonstrates the greatest uncertainty and the remaining alternatives are compressed relative to the output for the other sub-basins. The top performing alternatives are 4, 2A, and 2B and there is complete overlap between Alternative 4 and alternatives 2A and 2B.

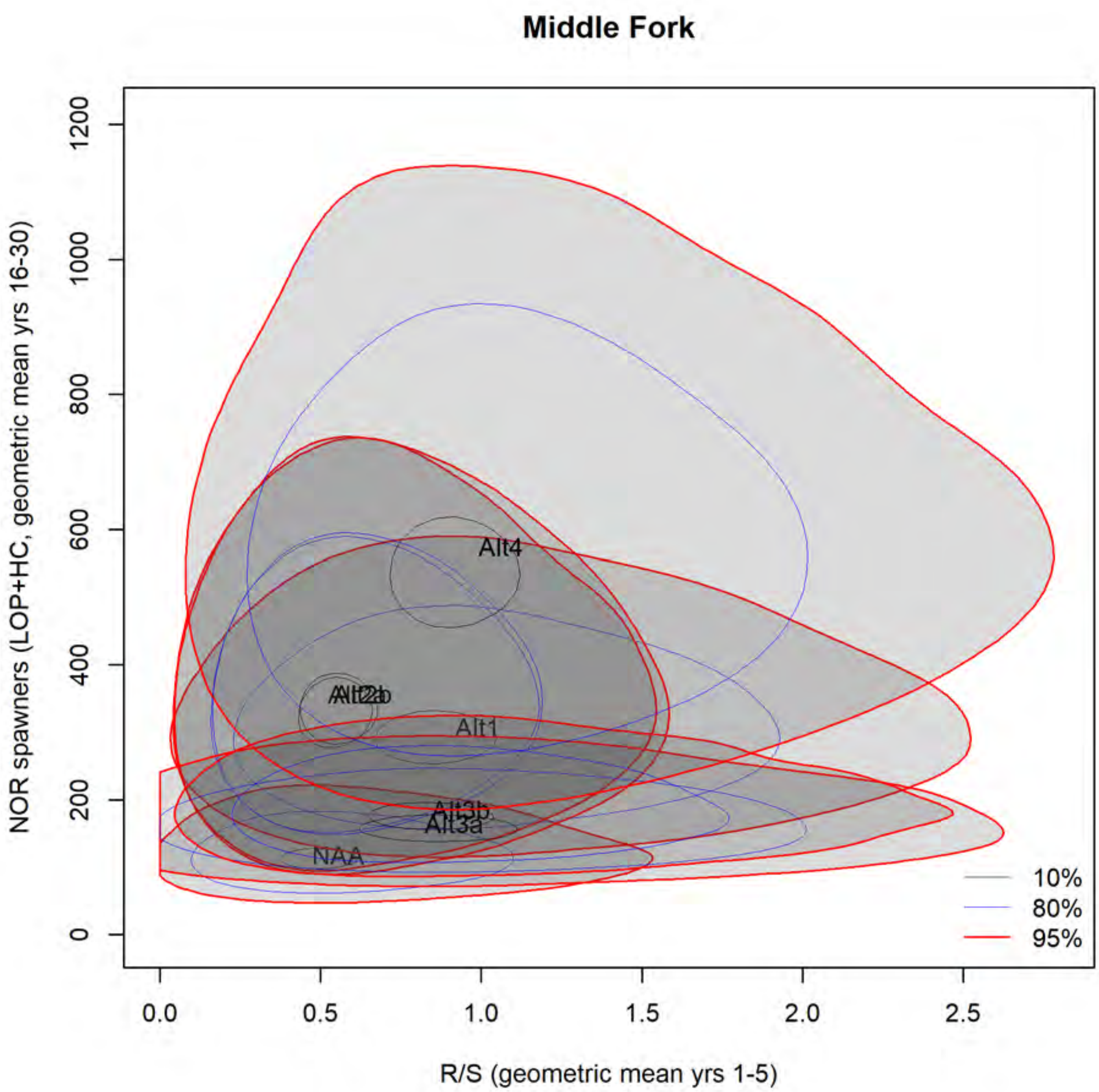



**Figure 3.8-19. Tradeoff plot for McKenzie Chinook salmon showing abundance regressed against maximum recruits per spawner. Alternatives are shown by bubbles and represent the range of possible values in each evaluation metric. Confidence bands are given by each color (10%, 80%, and 95% confidence).**

## 3.9 WILDLIFE AND HABITAT

The Willamette River Basin historically consisted of a multitude of aquatic and terrestrial habitat types that sustained rich assemblages of wildlife species. These assemblages include species that live year-round in its waters and associated floodplains, migratory species using seasonal habitat (e.g., breeding, wintering), wildlife movement corridors, and non-breeding/foraging habitats. Aquatic habitats are considered here to include open water (i.e., reservoir, main channel, secondary channels, backwaters, oxbows, and lakes/ponds) of varying depths. Terrestrial habitats generally include wetlands, forests, oak savannas, grasslands, and shrublands.

### 3.9.1 Affected Environment

The area of analysis for wildlife and their habitat (excludes fish, see Section 3.8) consists of all reservoirs up to the maximum pool elevation and the associated riverine and riparian habitat. A more detailed description of the Willamette River Basin and the associated subbasins can be found in Chapter 1. The Willamette River Basin is primarily composed of two EPA ecoregions: Willamette Valley and Western Cascades (see detailed ecoregions discussion in Section 3.6.1).

Open water habitat offers a diverse range of flows, depths, and temperature regimes, which provides habitat for mustelids, amphibians, reptiles, freshwater mussels, migratory birds, resident waterfowl, bats, and macroinvertebrates. Freshwater ecosystems support foraging, overwintering, reproduction, metamorphosis, and protection from predators for freshwater species.

Terrestrial habitats include grasslands, mixed deciduous and conifer riparian forest, mixed upland conifer forest, and oak-savannah habitats. The constantly changing and complex canopy structure produces changes in biomass and other ecosystem functions that effect faunal biodiversity. Upland systems provide species support by way of reproductive habitat for nesting and denning; refuge for roosting and overwintering; vertical and horizontal canopy structure for sunning and basking; and a variety of food resources throughout the seasons.

More specifically, grasslands and oak-savanna habitats provide browsing for native ungulates; seeds and insects for grassland birds; roots and fruits for rodents; and wildflowers for pollination and nectaring, and open space for invertebrates.

Tables 3.9-1 and 3.9-2 include species that have the potential to be present in the Willamette River Basin. Source data for tables in 3.9 include Oregon Biodiversity Information Center (ORBIC 2019), Oregon Department of Fish and Wildlife Sensitive Species list and Conservation Strategy, and USACE and USFWS species experts. This list does not include fish species (see Section 3.8)

Table 3.9-1 Representative common species that have the potential to be present in the Willamette River Basin, Oregon.

**Table 3.9-1. Common Species Present in all Subbasins**

| Taxon | Common Name | Scientific Name | North Santiam | South Santiam | McKenzie | Middle Fork | Coast Fork | Long Tom |
|---|---|---|---|---|---|---|---|---|
| Mammals | Roosevelt elk | *Cervus canadensis roosevelti* | x | x | x | x | x | x |
| Mammals | Black-tailed deer | *Odocoileus hemionus columbianus* | x | x | x | x | x | x |
| Mammals | Black bear | *Ursus americanus* | x | x | x | x | x | x |
| Mammals | Cougar | *Puma concolor* | x | x | x | x | x | x |
| Mammals | Coyote | *Canis latrans* | x | x | x | x | x | x |
| Mammals | Bobcat | *Lynx rufus* | x | x | x | x | x | x |
| Mammals | Striped skunk | *Mephitis mephitis* | x | x | x | x | x | x |
| Mammals | American beaver | *Castor canadensis* | x | x | x | x | x | x |
| Mammals | Muskrat | *Ondatra zibethicus* | x | x | x | x | x | x |
| Mammals | North American river otter | *Lontra canadensis* | x | x | x | x | x | x |
| Mammals | American mink | *Neovison vison* | x | x | x | x | x | x |
| Mammals | Short-tailed weasel | *Mustela erminea* | x | x | x | x | x | x |
| Mammals | Raccoon | *Procyon lotor* | x | x | x | x | x | x |
| Mammals | Virginia opossum | *Didelphis virginiana* | x | x | x | x | x | x |
| Mammals | Northern flying squirrel | *Glaucomys sabrinus* | x | x | x | x | x | x |
| Birds | Bald eagle | *Haliaeetus leucocephalus* | x | x | x | x | x | x |
| Birds | Osprey | *Pandion haliaetus* | x | x | x | x | x | x |
| Birds | Great blue heron | *Ardea herodias* | x | x | x | x | x | x |
| Birds | Mallard | *Anas platyrhynchos* | x | x | x | x | x | x |
| Birds | Common merganser | *Mergus merganser* | x | x | x | x | x | x |
| Birds | Wood duck | *Aix sponsa* | x | x | x | x | x | x |
| Birds | Bufflehead | *Bucephala albeola* | x | x | x | x | x | x |
| Birds | Ruffed grouse | *Bonasa umbellus* | x | x | x | x | x | x |
| Birds | Mountain quail | *Oreortyx pictus* | x | x | x | x | x | x |
| Birds | Band-tailed pigeon | *Patagioenas fasciata* | x | x | x | x | x | x |

| Taxon | Common Name | Scientific Name | North Santiam | South Santiam | McKenzie | Middle Fork | Coast Fork | Long Tom |
|---|---|---|---|---|---|---|---|---|
| Birds | Anna's hummingbird | *Calypte anna* | x | x | x | x | x | x |
| Birds | American robin | *Turdus migratorius* | x | x | x | x | x | x |
| Birds | Black-capped chickadee | *Poecile atricapillus* | x | x | x | x | x | x |
| Birds | Spotted towhee | *Pipilo maculatus* | x | x | x | x | x | x |
| Reptiles | Common garter snake | *Thamnophis sirtalis* | x | x | x | x | x | x |
| Reptiles | Western fence lizard | *Sceloporus occidentalis* | x | x | x | x | x | x |
| Amphibians | Pacific treefrog | *Pseudacris regilla* | x | x | x | x | x | x |
| Amphibians | Pacific giant salamander | *Dicamptodon tenebrosusis* | x | x | x | x | x | x |
| Amphibians | Rough-skinned newt | *Taricha granulosa* | x | x | x | x | x | x |
| Invertebrates | Pale swallowtail | *Papilio eurymedon* | x | x | x | x | x | x |
| Invertebrates | White-shouldered bumble bee | *Bombus appositus* | x | x | x | x | x | x |

Table 3.9-2 lists sensitive species and the subbasins in which they occur.

**Table 3.9-2. Sensitive Species Present in the Willamette River Basin, Oregon**

| Taxon | Common Name | Scientific Name | Federal Status[2] | Critical Habitat | Protective Regulations | State Status[3] | North Santiam | South Santiam | McKenzie | Middle Fork | Coast Fork | Long Tom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mammals | Gray wolf | *Canis lupus* | LE | Not Designated in Oregon | -- | SC | x | | | x | | |
| Mammals | Sierra Nevada red fox | *Vulpes vulpes necator* | -- | Not Designated | -- | S; CS | x | | x | x | | |
| Mammals | Ringtail | *Bassariscus astutus* | -- | Not Designated | -- | S; CS | | | x | x | | |
| Mammals | Pacific marten (interior) | *Martes caurina (pop. 1)* | -- | Not Designated | -- | S; CS | x | | | x | | |
| Mammals | Fisher | *Pekania pennanti* | -- | Not Designated | -- | SC; CS | x | x | x | x | | |
| Mammals | American pika | *Ochotona princeps* | -- | Not Designated | -- | S; CS | x | x | x | x | | |
| Mammals | Red tree vole | *Arborimus longicaudus* | C | Not Designated | -- | S; CS | x | x | x | x | x | |
| Mammals | Western gray squirrel | *Sciurus griseus* | -- | Not Designated | -- | S; CS | x | x | x | x | x | x |
| Mammals | California myotis | *Myotis californicus* | -- | Not Designated | -- | S; CS | x | x | x | x | x | x |
| Mammals | Fringed myotis | *Myotis thysanodes* | -- | Not Designated | -- | S; CS | x | x | x | x | x | x |
| Mammals | Hoary bat | *Lasiurus cinereus* | -- | Not Designated | -- | S; CS | x | x | x | x | x | x |
| Mammals | Little brown bat | *Myotis lucifiugus* | P | Not Designated | -- | -- | x | x | x | x | x | x |
| Mammals | Long-legged myotis | *Myotis volans* | -- | Not Designated | -- | S; CS | x | x | x | x | | |

| Taxon | Common Name | Scientific Name | Federal Status[2] | Critical Habitat | Protective Regulations | State Status[3] | North Santiam | South Santiam | McKenzie | Middle Fork | Coast Fork | Long Tom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mammals | Silver-haired bat | *Lasionycteris noctivagans* | SOC | Not Designated | -- | S | x | x | x | x | x | x |
| Mammals | Townsend's big-eared bat | *Corynorhinus townsendii* | -- | Not Designated | -- | SC; CS | x | x | x | x | x | x |
| Birds | Acorn woodpecker | *Melanerpes fornicivorus* | -- | Not Designated | -- | S; CS | x | | x | x | x | x |
| Birds | Black-necked stilt | *Himantopus mexicanus* | -- | Not Designated | -- | S; CS | | | | | | x |
| Birds | Caspian tern | *Hydroprogne caspia* | -- | Not Designated | -- | S; CS | | | | | | x |
| Birds | Chipping sparrow | *Spizella passerina* | -- | Not Designated | -- | S; CS | | | | | | x |
| Birds | Common nighthawk | *Chordeiles minor* | -- | Not Designated | -- | SC; CS | x | | | x | | x |
| Birds | Dusky Canada goose | *Branta canadensis occidentalis* | -- | Not Designated | -- | S; CS | | | | | | x |
| Birds | Grasshopper sparrow | *Ammodramus savannarum perpallidus* | -- | Not Designated | -- | SC; CS | x | | | | | x |
| Birds | Greater sandhill crane | *Antigone canadensis tabida* | -- | Not Designated | -- | S; CS | x | | | | | |
| Birds | Harlequin duck | *Histrionicus histrionicus* | -- | Not Designated | -- | S; CS | x | x | x | x | | |
| Birds | Lewis's woodpecker | *Melanerpes lewis* | -- | Not Designated | -- | SC; CS | | | x | x | x | x |
| Birds | Marbled murrelet* | *Brachyramphus marmoratus* | LT | Designated | 57 FR 45238 45337; 81 FR 51348 51370 | LT; CS | - | - | - | - | - | - |

| Taxon | Common Name | Scientific Name | Federal Status[2] | Critical Habitat | Protective Regulations | State Status[3] | North Santiam | South Santiam | McKenzie | Middle Fork | Coast Fork | Long Tom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Birds | Mountain quail | *Oreortyx pictus* | -- | Not Designated | -- | S; CS | x | | | x | x | x |
| Birds | Northern goshawk | *Accipiter gentilis atricaupillus* | -- | Not Designated | -- | S; CS | x | x | x | x | x | x |
| Birds | Northern spotted owl | *Strix occidentalis caurina* | LT | Designated | 55 FR 26114 26194; 86 FR 62606 62666 | LT | x | x | x | x | x | |
| Birds | Olive-sided flycatcher | *Contopus cooperi* | -- | Not Designated | -- | S; CS | x | x | x | x | x | x |
| Birds | Oregon vesper sparrow | *Pooecetes gramineus affinis* | SOC | Not Designated | -- | SC; CS | | | | | | x |
| Birds | Peregrine falcon (American) | *Falco peregrinus anatum* | -- | Not Designated | -- | S; CS | x | x | x | x | x | x |
| Birds | Pileated woodpecker | *Dryocopus pileatus* | -- | Not Designated | -- | S; CS | x | x | x | x | x | x |
| Birds | Purple martin (Western *subsp.*) | *Progne subis arboricola* | -- | Not Designated | -- | SC; CS | x | x | x | x | x | x |
| Birds | Streaked horned lark | *Eremophilia alpestris strigata* | LT | Designated | 78 FR 61451 61503; 78 FR 61505 61589 | SC; CS | | | | x | x | x |
| Birds | Western bluebird | *Sialia mexicana* | -- | Not Designated | -- | S; CS | x | | | x | x | x |
| Birds | Western meadowlark | *Sturnella neglecta* | -- | Not Designated | -- | SC; CS | x | | | | x | x |
| Birds | White-breasted nuthatch | *Sitta carolinensis aculeata* | -- | Not Designated | -- | S; CS | x | x | x | x | x | x |

| Taxon | Common Name | Scientific Name | Federal Status[2] | Critical Habitat | Protective Regulations | State Status[3] | North Santiam | South Santiam | McKenzie | Middle Fork | Coast Fork | Long Tom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Slender-billed) | | | | | | | | | | | |
| Birds | Willow flycatcher | *Empidonax traillii* | -- | Not Designated | -- | SC; CS | x | | | x | x | x |
| Birds | Yellow-billed cuckoo* | *Coccyzus americanus* | LT | Designated | 79 FR 59991 60038; 86 FR 20798 21005 | -- | - | - | - | - | - | - |
| Birds | Yellow-breasted chat | *Icteria virens auricollis* | -- | Not Designated | -- | SC; CS | x | | | x | x | x |
| Reptiles | Northwestern pond turtle | *Actinemys marmorata* | SOC; P | Not Designated | -- | SC; CS | x | x | x | x | x | x |
| Reptiles | Western painted turtle | *Chrysemys picta bellii* | -- | Not Designated | -- | SC; CS | x | x | x | | | |
| Reptiles | Western rattlesnake | *Crotalus oreganus* | -- | Not Designated | -- | SC; CS | | | | x | x | |
| Amphibians | Cascade torrent salamander | *Rhyacotriton cascadae* | P | Not Designated | -- | S; CS | x | x | x | | | |
| Amphibians | Cascades frog | *Rana cascadae* | SOC; P | Not Designated | -- | S; CS | x | x | x | x | | |
| Amphibians | Clouded salamander | *Aneides ferreus* | -- | Not Designated | -- | S; CS | x | x | x | x | x | x |
| Amphibians | Coastal tailed frog | *Ascaphus truei* | -- | Not Designated | -- | S; CS | | x | x | x | | |
| Amphibians | Foothill yellow-legged frog | *Rana boylii* | SOC | Not Designated | -- | SC; CS | x | x | x | | | |

| Taxon | Common Name | Scientific Name | Federal Status[2] | Critical Habitat | Protective Regulations | State Status[3] | North Santiam | South Santiam | McKenzie | Middle Fork | Coast Fork | Long Tom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Amphibians | Northern red-legged frog | *Rana aurora* | SOC | Not Designated | -- | S; CS | x | x | x | x | x | x |
| Amphibians | Oregon slender salamander | *Batrachoseps wrighti* | SOC | Not Designated | -- | S; CS | x | x | x | x | | |
| Amphibians | Western toad | *Anaxyrus boreas* | -- | Not Designated | -- | S; CS | x | x | x | x | x | |
| Invertebrates | California floater mussel | *Anodonta californiensis* | SOC | Not Designated | -- | -- | x | x | x | x | x | x |
| Invertebrates | Western ridged mussel | *Gonidea angulata* | P | -- | -- | CS | x | x | x | x | x | x |
| Invertebrates | Winged floater freshwater mussel | *Anodonta nuttalliana* | -- | Not Designated | -- | CS | x | x | x | x | x | x |
| Invertebrates | Fender's blue butterfly | *Icaricia icarioides fenderi* | LE | Designated | 65 FR 3875 3 890; 71 FR 63862 63977 | CS | | | | | | x |
| Invertebrates | Monarch butterfly | *Danaus plexippus* | C | Not Designated | 85 FR 81813 | CS | x | x | x | x | x | x |
| Invertebrates | Taylor's checkerspot butterfly* | *Euphydryas editha taylori* | LE | Designated | 76 FR 66370 66439; 78 FR 61505 61589 | CS | - | - | - | - | - | - |
| Invertebrates | Suckley cuckoo bumble bee** | *Bombus suckleyi* | P | Not Designated | -- | -- | - | - | - | - | - | - |
| Invertebrates | Western bumble bee | *Bombus occidentalis* | P | Not Designated | -- | CS | x | x | x | x | | |

* Occurs in the Willamette Valley River Basin, but presence data are lacking in these 6 subbasins.

**Could be present in the Willamette Valley Basin, but systematic surveys are lacking in these 6 subbasins.

[1]ORBIC, 2019; ODFW Oregon Sensitive Species List and Conservation Strategy

[2] LE = Listed Endangered; LT = Listed Threatened; SOC = Species of Concern; P = Petitioned for listing; C = Candidate for listing

[3] LT = Listed Threatened; S = Sensitive; SC = Sensitive Critical; CS = Conservation Strategy

### *3.9.1.1 North Santiam Subbasin*

The North Santiam Subbasin includes aquatic and terrestrial habitat associated with the Detroit Reservoir, the Big Cliff Reservoir, and the North Santiam River downstream of Big Cliff Dam to the confluence with the South Santiam River (see detailed subbasin descriptions in Chapter 1).

The North Santiam Subbasin sits at an elevation of approximately 1,565 feet NGVD (National Geodetic Vertical Datum) and is with in the Cascade Mountain region. Therefore, seasonal temperatures tend to be cooler than other subbasins in the Willamette Valley and will thus affect the species present.

Sensitive species such as the inland distribution of Pacific marten (*Pekania pennanti*) or red tree vole (*Arborimus longicaudus*) may acquire food and shelter in the dense canopy of the Cascades. Riverine and open water habitat in the North Santiam Subbasin provides cold, freshwater for common species such as the American beaver (*Castor canadensis*) and American mink (*Neovison vison*). These species use debris to build shelter and find a variety of food resources (fish, snakes, crustaceans, amphibians) in and around the Detroit and Big Cliff reservoirs.

Invertebrate surveys have not been conducted at the Foster and Green Peter Reservoirs by Corps staff, therefore we recognize there are a variety of data deficient species that could be present in these areas that are not presented here.

### *3.9.1.2 South Santiam Subbasin*

The South Santiam Subbasin includes the Green Peter and Foster Dams and Reservoirs (see Chapter 1). It is located within the western slope of the Cascades. Areas of urban development can be seen near Sweet Home, Oregon, which is located downstream of Green Peter Dam and adjacent to Foster Dam. Additionally, agricultural lands are interspersed along the South Santiam River northwest to Jefferson, Oregon.

Aquatic habitat, as in other subbasins, includes wetlands and open water associated with Green Peter and Foster reservoirs and the Middle Santiam and South Santiam rivers. Predominant habitat near Green Peter and Foster Dams consists of old growth, mixed coniferous forest, a mixed deciduous, and conifer riparian forest. Complex, thick forest structure and canopy cover provides an abundance of biomass and moist areas ideal for rough-skinned newts (*Taricha granulosa*) and secretive forest birds.

Common avian species include bald eagles (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), mallards (*Anas platyrhynchos*), common mergansers (*Mergus merganser)*, and buffleheads (*Bucephala albeola*) (Table 3.9-1). These species use the reservoirs for food resource and refuge.

Northwestern pond turtles (*Actinemys marmorata*), a State sensitive species and petitioned for Federal listing, are present at Sunnyside Park at Foster Reservoir (Table 3.9-2). Historic sightings of Northwestern pond turtles have been reported in other locations around Foster Reservoir, although no pond turtles have ever been located at Green Peter Reservoir. Additionally, Northern red-legged frogs (*Rana aurora)* are found at the Foster quarry and elsewhere around the reservoir. Foothill yellow-legged frog has been present historically, but no recent surveys have been conducted for this species. These reptiles and amphibians have been observed near the river and in satellite ponds managed by both the Corps and Linn County Parks.

Invertebrate surveys have not been conducted at the Foster and Green Peter Reservoirs by Corps staff, therefore we recognize there are a variety of data deficient species that could be present in these areas that are not presented here.

#### *3.9.1.3 McKenzie Subbasin*

The McKenzie Subbasin includes Cougar and Blue River Dams and Reservoirs (see Chapter 1) and are considered part of the EPA Ecoregion 4a (see Section 3.7.1). Like the North Santiam Subbasin, these dams are higher in elevation (1,558 and 1350 ft NGVD, respectively) than most Willamette Valley dams, and therefore the McKenzie Subbasin may include a different suite of species than lower elevation dams. This Western Cascades ecoregion is predominately comprised of western hemlock and Douglas fir forests.

Common game species such as Roosevelt elk (*Cervus canadensis roosevelti*), black-tailed deer, black bear (*Ursus americanus*), and cougar (*Puma concolor*) inhabit the region. Upland game birds include sooty grouse (*Dendragapus fuliginosus*), ruffed grouse (*Bonasa umbellus*), mountain quail (*Oreortyx pictus*), and band-tailed pigeon (*Patagioenas fasciata*). Furbearers include American beaver, raccoon (*Procyon lotor*) and, less commonly, North American river otter (*Lontra canadensis*), bobcat (*Lynx rufus*), and mink. Resident waterfowl such as mallards, common mergansers, and wood ducks (*Aix sponsa*) inhabit the river, reservoir, and riparian areas of the subbasin (Table 3.9-1).

Non-game wildlife commonly observed in this ecoregion include small mammals (chipmunks, squirrels, rabbits, and mice), bald eagles, osprey, and pacific treefrogs (*Pseudacris regilla*). Sensitive species include Harlequin ducks (*Histrionicus histrionicus),* Oregon slender salamanders (*Batrachoseps wrighti*), and the Townsend's big-eared bat (C*orynorhinus townsendii*) (Table 3.9-2). Bats forage along the reservoir and tributaries during warmer months and use tree cavities, bark, leaf litter, and artificial structures for roosting.

Systematic faunal surveys have not been conducted in and around Cougar and Blue River Reservoirs by Corps staff, therefore we recognize there are a variety of data deficient species that could be present that are not discussed here.

#### *3.9.1.4 Middle Fork Willamette River*

The Middle Fork Willamette Subbasin includes Hills Creek, Lookout Point, Dexter, and Fall Creek Dams and Reservoirs. This subbasin is located within the western slope of the Cascade Mountains. Most urban development is limited to the towns of Lowell and Oakridge, Oregon. Lowell is adjacent to Dexter Reservoir and within 10 miles of Fall Creek and Lookout Point Reservoirs. Oakridge and West Fir are near Hills Creek Dam. Hills Creek Dam is higher in elevation (1,545 ft NGVD) and closer the Cascade Mountains than the other three dams, therefore a unique suite of species, such as Northern red-legged frogs and the Harlequin ducks occur at Hills Creek.

Upland habitats found within the Middle Fork Subbasin include grasslands, riparian and mixed conifer forest, and a limited amount of oak savanna habitats. Vegetative heterogeneity and varying elevations near these dams provide habitat complexity that supports unique breeding, denning, roosting, basking, and foraging environments for a variety of wildlife species.

Common avian species observed at these reservoirs include bald eagles, osprey, bufflehead, Western grebes (*Aechmophorus occidentalis*), tree swallows (*Tachycineta bicolor*), and spotted towhees (*Pipilo maculatus*) (Table 3.9-1). Amphibians well-represented at Fall Creek and surrounding areas include rough-skinned newts and Oregon ensatinas (*Ensatina eschscholtzii oregonensis*), along with more unique salamanders such as the Dunn's (*Plethodon dunni*) and long-toed salamanders (*Ambystoma macrodactylum*). Moist soil and forested understory provide ideal habitat for salamander species around Fall Creek, Hills Creek, and Lookout Point Reservoirs.

Northwestern pond turtles (*Actinemys marmorata*), a State sensitive species and petitioned for Federal listing, occur in each of these four reservoirs and are typically found in protected reservoir coves or tributaries containing basking structures (logs or rocks). Other sensitive species present at these reservoirs include clouded salamanders (*Aneides ferreus*) and western bluebirds (*Sialia mexicana*) (Table 3.9-2).

Populations of waterfowl, both resident and migratory, use the reservoirs for foraging and refuge. Mesopredators such as bobcats (*Lynx rufus*) and coyotes (*Canis latrans*) are also found around the reservoirs.

#### *3.9.1.5 Coast Fork Willamette River*

The Coast Fork Willamette Subbasin includes Cottage Grove and Dorena Dams and Reservoirs. The forests within the subbasin are dominated by Douglas fir with some remnant oak forests (see Chapter 1). The town of Cottage Grove, Oregon lies within 7 miles of both reservoirs and is the most developed urban area near the reservoirs. Private properties also line the perimeter of these reservoirs. The Coast Fork Willamette River riparian corridor consists of agricultural fields with limited forested habitat up to confluence with the Middle Fork Willamette River near Eugene, Oregon.

The upland habitats near these reservoirs include grasslands, riparian forest, mixed conifer forest, agricultural lands, and oak savanna habitats. More specifically, mixed deciduous and conifer riparian forests make up most of the habitat at Dorena and Cottage Grove Reservoirs.

Common avian species observed at these reservoirs include bald eagles, osprey, and hooded mergansers (*Lophodytes cucullatus*)**.** Amphibians include long-toed salamanders, rough-skinned newts, and Oregon ensatinas (Table 3.9-1).

Sensitive species, such as the Northwestern pond turtle, have historically been seen in and around Dorena and Cottage Grove Reservoirs (Table 3.9-2). A small population of western purple martins (*Progne subis arboricola*) is supported by artificial nest boxes at Cottage Grove Reservoir.

Systematic faunal surveys have not been conducted in and around Dorena and Cottage Grove Reservoirs by Corps staff, therefore we recognize there are a variety of data deficient species that could be present in these areas that are not discussed here.

#### *3.9.1.6 Long Tom*

The Long Tom River Subbasin includes Fern Ridge Dam and the Long Tom River upstream of its confluence with the Willamette River (see Chapter 1). The Long Tom River downstream of Fern Ridge Dam was modified for conveyance soon after Fern Ridge Dam was built in the 1940s. To promote high flows through the modified channel of the Long Tom River, large trees including cottonwood, oak, and Oregon ash were removed along with smaller shrubs (e.g., various willow species). In addition, the channel was modified by straightening it through the floodplain; however, unmodified portions of the Long Tom River channel remain. Natural occurring oxbows and sloughs are connected to the current Long Tom River channel via culverts. In other portions of the Long Tom River, the original channel was cut off from the constructed channel to decrease channel length and are no longer connected to the current Long Tom River channel. Those oxbows and sloughs provide off-channel wetland and open water habitat.

Adjacent land use along the Long Tom River is predominately agriculture, with grass seed propagation the dominant crop. Remnant native oak riparian forest areas dot the landscape along the unmodified portion of the Long Tom River channel south of Monroe, Oregon.

Adjacent land use around Fern Ridge Reservoir includes a mix of residential and agricultural. Habitat types within Fern Ridge Reservoir include upland Willamette Valley prairie, Willamette Valley wet-prairie, oak woodland, riparian forest remnants, emergent vegetation, and open water. Constructed wetland cells at the southeastern end of Fern Ridge Reservoir are managed for winter waterfowl use by the Oregon Department of Fish and Wildlife (ODFW).

Common species include voles, chipmunks, bats, and rabbits. Roosevelt elk and black-tailed deer are also seen along the reservoir shores (Table 3.9-1). Resident and migratory waterfowl use the reservoir for both breeding and wintering. Various shorebirds forage in the exposed lakebed during the winter reservoir drawdowns. A variety of secretive marsh birds use the emergent lake vegetation for breeding. Fern Ridge Reservoir and surrounding wetlands are renowned for the abundance and diversity of avian species. Occasional migrant raptors like snowy owls (*Bubo scandiacus*) and migrating winter shorebirds such as dunlin (*Calidris alpina*) and black-bellied plovers (*Pluvialis squatarola*) can be observed.

Unique and sensitive species found in and around Fern Ridge Reservoir and the Long Tom River channel include Northwestern pond turtles, grasshopper sparrows (*Ammodramus savannarum*), western purple martins, Fender's blue butterflies (*Icaricia icarioides fender*), and streaked horned larks (*Eremophila alpestris strigata*) (Table 3.9-2). Northwestern pond turtles are seen throughout the reservoir and are concentrated in Kirk Pond and Park, directly north of the dam. Grasshopper sparrows and Fender's blue butterflies inhabit the remanent native upland prairie that surrounds the reservoir. Every spring and summer, migratory western purple martins take advantage of artificial nest boxes that surround Fern Ridge Reservoir. This population is thought to be the largest population of inland nesting purple martins in Oregon. A small breeding assemblage of streaked horned larks are found at the southern end of the reservoir, south of Highway 126. Periodic reports of streaked horned lark calls have been reported near the Fisher Butte unit, just north of the highway. Streaked horned larks require large expanses of open ground with sparse vegetation and vernal pools for breeding and foraging. Fern Ridge's Coyote units provide this essential habitat.

### 3.9.2 Environmental Consequences

This section discusses the potential effects of the alternatives on wildlife and associated habitats. The area of analysis, as previously mentioned, consists of all reservoirs up to the maximum pool elevation (a.k.a., "full pool"), the terrestrial habitat around the reservoirs, riverine habitat downstream of the dams, and the associated riparian corridors along the project stream reaches listed below.

- Middle Fork Willamette River downstream of Hills Creek Dam to the confluence with the Coast Fork Willamette River;
- Coast Fork Willamette River downstream of Cottage Grove Dam to the confluence with the Middle Fork Willamette River;
- Row River from downstream of Dorena Dam to the confluence with the Coast Fork Willamette River;
- South Fork McKenzie River downstream of Cougar Dam to the confluence with the McKenzie River;

- McKenzie River from the South Fork McKenzie River confluence to the confluence with the Willamette River;
- Blue River downstream of Blue River Dam to the confluence with the McKenzie River;
- Long Tom River downstream of Fern Ridge Dam to the confluence with the Willamette River (includes Coyote Creek from Fern Ridge Dam to the confluence with the Willamette River);
- South Santiam River downstream of Foster Dam to the confluence with the North Santiam River;
- North Santiam River downstream to the confluence with the South Santiam River;
- Santiam River to the confluence with the Willamette River; and
- Willamette River mainstem to Willamette Falls.

The discussion below includes the qualitative methods used to evaluate effects to wildlife and associated habitat.

#### *3.9.2.1 Methodology*

The method used to assess the existing conditions and the alternatives' effects to wildlife, birds, and associated habitat was a qualitative analysis based on species presence or absence or suitable habitat present as shown in ORBIC, USFWS, and ODFW conservation strategy data as well as direct coordination with USFWS species experts. In addition, it should be noted that the Corps employs biologists in the Willamette Valley who have expertise in both common and rare species and habitats throughout the Willamette River Valley and they reviewed species included in the DPEIS.

Potential effects to wildlife and associated habitats within the WVS analysis area entail indirect effects related to hydrology, water quality, and fish passage measures proposed for each alternative. The following measures (described in Chapter 2) have effects on wildlife and associated habitat that will be evaluated in this Draft PEIS:

- Gravel augmentation below dams (#384);
- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9);
- Integrated temperature and habitat flow regime (#30a);
- Refined integrated temperature and habitat flow regime (#30b);
- Construct water temperature control (WTC) tower (#105);
- Augment instream flows by using inactive pool (#718);
- Reduce minimum flows to Congressionally authorized minimum flow requirements (#723);
- Augment instream flows by using the power pool (#304);

- Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166)
- Structural improvements to reduce total dissolved gas (#174)
- Foster Fish Ladder Temperature Improvement (#479)
- Use spillway for surface spill in summer (#721)
- Construct structural downstream fish passage (#392);
- Pass water over spillway in spring for fish passage (#714);
- Provide Pacific lamprey passage and infrastructure (#52);
- Restore upstream and downstream passage at drop structures (#639);
- Deeper fall reservoir drawdowns for fish passage (#40); and
- Spring reservoir drawdown for downstream fish passage (#720).

Measures that would be not likely to affect wildlife and wildlife habitat as part of the WVS O&M program include the following: Adapt Hatchery Program (#719), Maintenance of existing and new fish release sites above dams (#726), and Construct adult fish facility (#722) (pertaining to fisheries management activities). These measures are not discussed further in regard to effects to wildlife and wildlife habitat.

Direct effects to wildlife or associated habitats may be included as part of specific construction activities; however, this Draft PEIS will discuss general qualitative effects from construction at the programmatic level. Site-specific project details for each construction measure will be determined during the implementation phase. Subsequent tiered NEPA documents would discuss the detailed site-specific effects. At that time, site-specific biological data would be reviewed to determine species presence and suitable habitat located within a specific project action area to determine the direct effects. Applicable permits, approvals, and environmental clearances would be obtained prior to action implementation. If ESA Section 7 formal or informal consultation with USFWS for a particular ESA-listed species or its designated critical habitat would be required for a particular action, this would be pursued at that time.

**All comparisons of magnitude or duration in the effects analysis for each action alternative are in comparison to the NAA unless stated otherwise.**

Table 3.9-23 below describes the criteria for the scale of effects for wildlife and associated habitat within the WVS.

**Table 3.9-3. Evaluation Criteria for Potential Effects**

| Effect Scale | Definition |
|---|---|
| **Magnitude** | |
| None/negligible | Species and/or habitat would not be affected and no effects (e.g., noise disturbance, physical harm, etc.) would be detectable. |
| Minor | Effects to the species and/or habitat would be detectable (e.g., vacated habitats, evidence of a lethal effect to individuals, improvement of habitat function); however, effects would be only to a small number of individuals and would be localized. |
| Moderate | Effects to the species and/or habitat would be measurable and include effects (e.g., lethal wildlife effects, loss of suitable habitat) at the population and subbasin scale. |
| Major | Effects to species and/or habitat (e.g., lethal wildlife effects, loss of habitat for special status species, effects to designated critical habitat) would be measurable and would have substantial ecological consequences at the population scale for multiple subbasins within the WVS. Mitigation measures to reduce the adverse effects would be required, though long-term population effects would be anticipated. |
| **Duration** | |
| Short-term | Effect to species and/or habitat would be short in duration lasting only as long as a discreet construction project or single event, e.g., construction noise. |
| Long-term | Effect to species and/or habitat would be ongoing or lasts beyond operation changes or the completion of construction projects. |

### *3.9.2.2 No Action Alternative*

The NAA hydrologic regime is the opposite of the natural hydrologic regime. The WSE is the highest within the reservoirs from May through September when the maximum conservation pool is being maintained, whereas naturally this would be the driest time of year within the reservoir area. This serves as a source of hydrology that helps sustain wetland and aquatic habitats along the edges and within the reservoirs, respectively, during the year when precipitation is at its lowest. Maximizing open water aquatic habitat within the summer months benefits a range of species including amphibians such as the northern red-legged frog, reptiles such as the northwestern pond turtle, wading birds, aquatic diving birds, waterfowl, and furbearers such as the American beaver. In addition, amphibians benefit from maintaining water levels in late winter through spring when egg masses require inundation to keep the eggs from drying out. Wetland fringe habitat supports the wildlife species by providing foraging, breeding, rearing, nesting, and sheltering habitat. Keeping the reservoirs full during the summer also provides easier access to water for a variety of upland wildlife species including, but not limited to, black-tailed deer, raccoons, voles, and Pacific martens (*Martes caurina*). Maximizing aquatic habitat available to wildlife species during summer months has moderate long-term benefits to both aquatic and terrestrial species.

Within the WVS, downstream flows are managed so that wintertime flooding, which would naturally occur without the dams, is mitigated. In addition, revetments within the WVS help ensure that banks are not overtopped in any sort of high flow event. These flood mitigation actions, limit the hydrologic connectivity across the floodplains of WVS streams. Therefore, adjacent aquatic and wetland habitats experience drier conditions than they would outside of a managed system. This limits the size and diversity of habitat within the riparian corridors that would be available to wildlife species during winter and spring months, which has moderate long-term adverse effects to aquatic wildlife and their habitat. Though this may be limiting to species that depend primarily on aquatic and wetland habitat, this likely has minor long-term benefits for upland species by expanding habitat otherwise unusable to them during winter months if there was widespread flooding within the floodplain.

No fish passage improvements would be proposed as part of the NAA. This would continue to limit foraging opportunities for piscivorous wildlife species such as river otters, muskrats (*Ondatra zibethicus*), and eagles within stream reaches upstream of the WVS dams where passage has not been provided for native migratory fish, including salmonids and Pacific lamprey (*Lampetra tridentata*). This would result in long-term, minor, adverse effects to piscivorous wildlife species and overall habitat function in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins.

Climate change is anticipated to lead to wetter Climate change is anticipated to lead to wetter, shorter winters with more punctuated precipitation events (greater intensity). Climate change will also yield longer, drier summers (increased temperature and evapotranspiration) which would adversely affect wildlife species and habitat in the Willamette Valley independent of the WVS operation and maintenance actions over the course of the next 30 years. Vegetation types present in upland habitat that support terrestrial wildlife species would shift to more drought-tolerant species. Wetland habitats within the riparian corridor would be drier during summer months, shrinking available habitat earlier in the year and will significantly affect species amphibians, reptiles, and those terrestrial species that rely on water bodies for foraging such as birds and bats. These changes to habitat may increase stress on wildlife species to find suitable habitat. In the case of amphibians, breeding success would be adversely affected, reptile foraging will be altered, and raptor prey-base will be diminished Additionally, climate change is anticipated to continue to increase water temperature over time as ambient temperatures increase and snowmelt contributes less runoff or earlier runoff within the basin, which could adversely affect wildlife prey species, such as fish. Increased water temperatures would cause a greater frequency of algal blooms, which can introduce toxins both to prey species (e.g., fish) as well as species higher up in the food chain that ingest these toxins. The seasonality of wildlife species (e.g., birds, reptiles, insects, etc.) life histories will be forced to adapt to the changing climate patterns, which is anticipated to have a number of adverse effects to species, interactions between species, and interactions with their habitats. Overall, climate change is anticipated to cause major, long-term, adverse effects to wildlife species and their habitat independent of the WVS operation and maintenance actions associated with the NAA as well as any other alternative.

### *3.9.2.3 Measures Common to All Action Alternatives*

Measures that are common to all action alternatives that would provide minor long-term benefits to wildlife habitat within the WVS include gravel augmentation below the dams (#384) and maintaining revetments using nature-based engineering or altering revetments for aquatic ecosystem restoration (#9).

Gravel augmentation below dams within the Middle Fork Willamette, McKenzie, South Santiam, and North Santiam subbasins is intended to improve instream spawning habitat for ESA-listed UWR Chinook and steelhead as well as other native fish; however, there would be minor indirect effects that benefit wildlife species and habitat. Improving conditions for fish and other aquatic organisms may improve foraging opportunities for piscivorous wildlife species such as osprey, diving ducks, river otters, and eagles. In addition, by adding gravel to these streams, there is more potential for sediment transport and accumulation along the stream margins, which may serve to better connect riverine wetlands to instream flows. In these areas, wetlands would benefit through improved hydrologic conditions over time. Wildlife species that would benefit from improvements to wetland habitat, include species such as American beavers, great blue herons (*Ardea Herodias*), frogs (*Rana* sp.), and turtles (painted and northwestern pond turtles). These beneficial effects are anticipated to be minor and long-term within the downstream reaches of the Middle Fork Willamette, McKenzie, South Santiam, and North Santiam subbasins.

In addition to the beneficial impacts to wildlife and habitat by the placement of gravel, there would some minor, short-term impacts to water quality and streambed habitat within the gravel placement areas and downstream of the placement sites. Placement of gravel would result in an increase to turbidity within the placement area and could impact aquatic invertebrates and native freshwater mussels within the placement area and those areas immediately downstream. Placement of gravel would also impact amphibian breeding areas (e.g. red-legged frog) within off-channel areas where suspended sediments would deposit. Dependent on the timing of the placement of gravel, there would be minor, short-term impacts to in-stream overwintering northwestern pond turtle.

In the same way, maintaining or altering revetments (through the Continuing Authority Program Section 1135 Project Modifications for Improvement of the Environment) is anticipated to improve habitat connectivity between upland and riparian vegetative communities along the stream margins, allowing for easier access to water for mammals (e.g., black-tailed deer, voles, ermine [*Mustela erminea*], muskrats, American beaver, etc.) and overland migration for amphibian species (e.g., Pacific giant salamanders [*Dicamptodon tenebrosusis*], rough-skinned newts [*Taricha granulosa*], etc.). These bio-engineered areas would provide better habitat for American beaver and river otter slides and nesting habitat for ground nesting birds through the incorporation of plants. The logs incorporated into the designs could potentially provide basking opportunities for turtles. These improvements to the revetments are anticipated to provide minor long-term beneficial effects for wildlife species and habitat. It should also be noted that it is uncertain how much of this could occur since the revetments are engineered bank stabilization and a limited number of these could be modified as discussed in Chapter 2.

#### *3.9.2.4 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

One measure associated with Alternative 1 that would affect aquatic and adjacent wetland wildlife habitat over the NAA is reducing minimum flows to the Congressionally authorized minimum flow requirements (#723) to benefit reservoir refill objectives within the entire WVS. Therefore, there would be a slight overall decrease in flows at the North Santiam and South Santiam rivers as well as Fall Creek, which flows into the Middle Fork Willamette. However, the decrease in flow is very minor and therefore, hydrologic effects to the aquatic and riverine wetland habitat along these streams would be negligible and long-term. There would though be a slight increase of downstream flows from the Dexter and Lookout Point Dams, which are along the Middle Fork Willamette. This increase in downstream flow would slightly improve hydrologic conditions for the aquatic and riverine wetland habitat, though the benefit to wildlife species is anticipated to be negligible and long-term over the NAA conditions.

Augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718) are proposed to augment stream flows during the late summer and fall. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Cougar, Green Peter, and Detroit and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Fall Creek, Blue River, Cottage Grove, and Dorena. These measures would have negligible long-term effects to riverine wetland and aquatic habitats downstream of the dams because water levels in downstream reaches would not be measurably affected. However, within the reservoirs there would be an effect to wildlife access to the water's edge during the late summer and fall, which is typically a dry time of year. Wildlife species would have to travel slightly farther than usual. However, these slight drawdowns would not occur during the wildlife breeding season (spring) so these measures are anticipated to have minor, long-term, adverse effects to terrestrial wildlife species within the Middle Fork Willamette, McKenzie, South Santiam, and North Santiam subbasins. Impacts to amphibians and reptiles, notably northwestern pond turtle, would be moderate, long-term adverse effects. The lowering of reservoir level would impact northwestern pond turtles that overwinter within the reservoir lakebed causing them to move throughout the drawdown period leading to an increase in energy expenditure. For those turtles that overwinter in upland areas adjacent to the reservoirs, lower reservoir elevations would increase travel distance to overwintering habitat leading to an increase in energy expenditure.

Alternative 1 includes measures to Provide Pacific lamprey passage and infrastructure (#52) at Dexter Dam; Restore upstream and downstream passage at drop structures (#639) at Long Tom River downstream of Fern Ridge; and downstream fish passage at Detroit (operation not a structure), Foster, Green Peter, and Lookout Point Dams (Measure 392). In addition, Alternative

1 measures that would improve salmonid survival by improving TDG levels include structural improvements to reduce TDG (#174) and by improving water temperature include constructing WTC towers (#105); using ROs to discharge colder water (#166); the Foster Fish Ladder Temperature Improvement (#479); and using the spillway for surface spill in summer (#721). Fish passage and water quality measures would improve lamprey populations in the Middle Willamette subbasin and salmonid populations in the North Santiam, South Santiam, McKenzie, Long Tom, and Middle Willamette subbasins. Improving fish populations would provide long-term minor benefits in terms of increased foraging opportunities for piscivorous wildlife species including but not limited to river otters, snakes, raccoons, ermine, eagles, osprey, great blue herons, etc. In addition, improving anadromous salmonid populations in the North Santiam, South Santiam, Long Tom, and Middle Willamette subbasins would have minor long-term benefits to habitat functions related to nutrient cycling as a result of fish decaying in these subbasins after spawning.

As compared with the NAA, conditions for terrestrial wildlife would remain status que as upland habitats would have negligible effects. Conditions for aquatic and semi-aquatic wildlife would also remain status que long-term for many species. Impacts to turtles and amphibians within the reservoirs could see a decline over the long-term.

#### *3.9.2.4.1 Climate Change*

The climate change effects in addition to the NAA (Section 3.9.2.2.), Alternative 1 has climate change concerns as well. The climate change effects regarding the NAA are concerns for Alternative 1 as well. However, maximizing water storage while also providing fish passage benefits to wildlife and wildlife habitat by providing maximum hydrologic support for aquatic and wetland habitats and increasing foraging opportunities for wildlife species upstream of the dams is anticipated to support wildlife species and habitat to the extent possible while these regional changes occur. Alternative 1 would not avoid the effects of climate change to wildlife and associated habitats but would potentially decrease the effects. However, major long-term adverse effects to wildlife species and habitat as a result of climate change would still be anticipated.

#### *3.9.2.4.2 Alternative 1 Wildlife, Birds, and Terrestrial Habitat Effects Summary Table*

Table 3.9-24 below presents a summary of the effects to wildlife and wildlife habitat within the WVS as a result of implementation of Alternative 1.

**Table 3.9-4. Summary of Effects for Wildlife, Birds, and Terrestrial Habitat under Alternative 1 as Compared to the Alternative 1 – Improve Fish Passage Through Storage-Focused Measures**

| Subbasin | Alternative 1 |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with minor benefits to aquatic and wetland habitat<br>North and South Santiam rivers - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Green Peter, Detroit, Foster – water quality improvements with minor benefits for foraging wildlife<br>Green Peter and Detroit - drawdowns with minor effects to wildlife and wildlife habitat around the reservoirs<br>Green Peter, Foster, and Detroit – downstream fish passage with minor benefits in the form of foraging and nutrient cycling |
| Long Tom Subbasin | Long Tom – downstream fish passage with minor benefits in the form of foraging and nutrient cycling |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with benefits to aquatic and wetland habitat<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Cougar – water quality improvements with minor benefits for foraging wildlife<br>Cougar - drawdowns with minor effects to aquatic and wetland habitat at the reservoirs |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with benefits to aquatic and wetland habitat<br>Middle Fork Willamette - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Dexter, Lookout Point Green Peter, Detroit, Foster – water quality improvements with minor benefits for foraging wildlife<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor effects to aquatic and wetland habitat at the reservoirs<br>Lookout Point and Dexter - downstream fish passage with minor benefits in the form of foraging and nutrient cycling |
| Coast Fork of the Willamette Subbasin | Cottage Grove and Dorena – drawdowns with minor effects to aquatic and wetland habitat at the reservoirs |

| Subbasin | Alternative 1 |
|---|---|
| Mainstem Willamette River | Negligible change |

### *3.9.2.5 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam)*

In terms of effects to wildlife, birds, and terrestrial habitat, as a hybrid of the rest of the alternatives, Alternative 2A includes minor changes to habitat, habitat access, and foraging opportunities. The integrated temperature and habitat flow regime (#30a) would have negligible effects to riverine wetlands and aquatic habitat within the North Santiam, South Santiam, McKenzie, Coast Fork Willamette, Middle Fork Willamette, and Long Tom subbasins.

Augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718) are proposed to augment stream flows during the late summer and fall. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Cougar, Green Peter, and Detroit and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Fall Creek and Blue River. These measures would have negligible long-term effects to riverine wetland and aquatic habitats downstream of the dams because water levels in downstream reaches would not be measurably affected. However, changes to peak flow event timing could impact reproduction timing of amphibian species, freshwater mussels, and other native aquatic species. Within reservoirs, the seasonal drawdown may cause wildlife to seek alternative water sources near the reservoirs during the drawdown time periods. However, these slight drawdowns would not occur during the wildlife breeding season (spring) so these measures are anticipated to have minor long-term adverse effects to wildlife species within the Middle Fork Willamette, Coast Fork Willamette, McKenzie, South Santiam, and North Santiam subbasins.

In addition, a measure that would affect wildlife, birds, and terrestrial habitat within the WVS as part of Alternative 2A includes a deeper fall reservoir drawdown for fish passage (#40) at Green Peter reservoir (October 15 to December 15). The drawdown would affect wildlife species' access to the water during these time periods within the South Santiam and McKenzie subbasins. Species such as black-tailed deer, elk, raccoons, ermine, coyotes (*Canis latrans*), etc. would need to travel farther to get to the water's edge and in some areas, may need to cross steep unvegetated slopes. The seasonal drawdown may cause wildlife attempting to access the water's edge to access alternative water sources in the vicinity of the reservoirs during the drawdown time periods. In addition, the drawdowns would affect wildlife species that build lodges, burrows, or dens along the water's edge such as beavers, muskrats, otters, etc. The dramatic changes in water surface elevations in these reservoirs throughout the year would flood these habitat structures at certain times of year and leave them high and dry at other times. This may cause animals to build multiple habitat structures throughout the year in these locations. Increasing the distance that wildlife would need to travel to access the water's edge and potentially damaging wildlife habitat structures through water level fluctuations would have long-term moderate effects on wildlife species, primarily mammalian species in the South Santiam subbasin.

Alternative 2A would include providing Pacific lamprey passage and infrastructure (#52) at Green Peter and constructing structural downstream fish passage (#392) at Detroit, Foster, Cougar, and Lookout Point. In addition, Alternative 2A measures that would improve water temperature include constructing WTC towers (#105); using ROs to discharge colder water (#166); the Foster Fish Ladder Temperature Improvement (#479); and using the spillway for surface spill in summer (#721) that would improve salmonid survival. These measures would improve fish passage, water quality, and would improve lamprey populations in the South Santiam subbasin and salmonid populations in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins. Improving fish populations would provide long-term minor beneficial effects in terms of increased foraging opportunities for piscivorous wildlife species including, but not limited to, river otters, snakes, racoons, weasels, eagles, osprey, great blue herons, etc.

As compared with the NAA, conditions for terrestrial wildlife would remain status que as upland habitats would have negligible effects. Conditions for aquatic and semi-aquatic wildlife would also remain status que long-term for many species. Impacts to turtles and amphibians within the reservoirs could see a decline over the long-term.

#### *3.9.2.5.1 Near-term Operations Measure*

The descriptions of the near-term operations measure can be found within Chapter 2. The analysis of effects of the near-term operations measure on wildlife, birds, and terrestrial habitat is broken down into subbasins.

**North Santiam Subbasin**

The near-term operations measure within the North Santiam Basin includes fall/winter downstream fish passage through the upper ROs and spring fish passage through strategic use of spillway and turbines at Detroit Dam and spreading spill to reduce TDG at Big Cliff Dam.

The use of the upper ROs for downstream fish passage in the fall may result in an increase in TDG downstream of Detroit Dam. Changes in fish survivorship could indirectly affect piscivorous wildlife; however, improving fish passage is anticipated to improve overall fish survivorship. Increases to fish survival would provide long-term minor beneficial effects to piscivorous wildlife species in terms of increased foraging. Wildlife species that would benefit include, but are not limited to, river otters, bald eagles, osprey, mergansers, and great blue herons.

Using the spillway for spring fish passage could lower reservoir elevations, resulting in changes to access to the reservoir for wildlife species during the conservation season. Wildlife species would need to find alternate water sources other than the reservoir or traverse steep, unvegetated slopes to get to the reservoir, which would have short-term, minor, adverse effects. Impacts to amphibians and reptiles, notably northwestern pond turtle, would be moderate, long-term adverse effects. The lowering of reservoir level would impact northwestern pond turtles that overwinter within the reservoir lakebed causing them to move throughout the drawdown period leading to an increase in energy expenditure. For those turtles that overwinter in upland areas adjacent to the reservoirs, lower reservoir elevations would increase travel distance to overwintering habitat leading to an increase in energy expenditure.

**South Santiam Subbasin**

The near-term operations measure within the South Santiam Subbasin includes outplanting of adult Chinook above Green Peter Reservoir, downstream fish passage at Green Peter Dam via the spillway in the spring and fall, and downstream fish passage at Foster via the spillway in the spring and fall.

The outplanting of Chinook salmon above Green Peter Dam would have a minor long-term benefit to piscivorous wildlife through increased foraging opportunities. Wildlife species impacted would include, but not limited to, bald eagles, river otters, great blue heron, osprey, and mergansers.

The use of the spillway for spring fish passage would affect wildlife species access to water within the reservoir. Wildlife species would need to find alternate water sources other than the reservoir or traverse steep, unvegetated slopes to get to the reservoir, which would have short-term, minor, adverse effects. Impacts to amphibians and reptiles, notably northwestern pond turtle, would be moderate, long-term adverse effects. The lowering of reservoir level would impact northwestern pond turtles that overwinter within the reservoir lakebed causing them to move throughout the drawdown period leading to an increase in energy expenditure. For those turtles that overwinter in upland areas adjacent to the reservoirs, lower reservoir elevations would increase travel distance to overwintering habitat leading to an increase in energy expenditure.

The deep fall drawdown at Green Peter from September to mid-December for fish passage would further impact wildlife access to available surface water during the fall and early winter months. Wildlife structures (e.g., lodges and burrows) would likely be constructed at multiple elevations within the reservoir. The dramatic changes in water elevation between the spring spill for downstream fish passage and the fall drawdown and spill for fish passage would result in long-term minor effects to wildlife.

The use of the spillway at Foster in the spring would occur from February 1 to May 15 and in the fall would occur from approximately Labor Day to December 15. The effects to wildlife are similar to the fish passage near-term operations measure at Green Peter. Wildlife would either have to travel farther or traverse steep unvegetated slopes of the reservoir to access surface water.

**Long Tom Subbasin**

There are no local operations proposed under the near-term operations measure within the Long Tom subbasin, therefore, there would be no effects of this measure to wildlife in this subbasin.

**McKenzie Subbasin**

The near-term operations measure within the McKenzie Subbasin include spring and fall/winter drawdown at Cougar Reservoir to a target elevation of 1,505 feet. This action would affect wildlife species access to water within the reservoir. Wildlife would have to either travel farther to access surface water or traverse steep, unvegetated slopes of the reservoir. Wildlife that construct burrows (e.g. river otters) or lodges (beaver) would have to construct additional wildlife structures at various elevations to adjust to the change in the reservoir elevation. The increase in fish passage survival would have a minor affect to piscivorous wildlife in the long-term with an increase in abundance of prey within the subbasin. Impacts to amphibians and reptiles, notably northwestern pond turtle, would be moderate, long-term adverse effects. The lowering of reservoir level would impact northwestern pond turtles that overwinter within the reservoir lakebed causing them to move throughout the drawdown period leading to an increase in energy expenditure. For those turtles that overwinter in upland areas adjacent to the reservoirs, lower reservoir elevations would increase travel distance to overwintering habitat leading to an increase in energy expenditure.

**Middle Fork Willamette Subbasin**

The near-term operations measure within the Middle Fork Willamette Subbasin include use of the regulating outlet for downstream fish passage at Hills Creek, deep drawdown for fish passage at Lookout Point in fall/winter, use of the spillway for fish passage at Lookout Point in the spring, use of the Lookout Point ROs for temperature management in the summer and fall, and a deep drawdown for fish passage in the fall at Fall Creek. For the operations at Lookout Point, storage at Hills Creek would be used for refilling Lookout Point in early March.

Similar to other near-term operations measure, the lower reservoir elevations at Lookout Point and at Hills Creek would affect wildlife access to water within the reservoir. Wildlife would either have to travel farther to access surface water or traverse steep, unvegetated slopes of the reservoir.

Northwestern pond turtles would have to travel longer distances to reach suitable upland nesting areas within Lookout Point, Hills Creek, and Fall Creek. Other wildlife species which build burrows or other structures would have to build multiple structures at various elevations to adjust to the changes in reservoir elevation.

The increase in fish passage within the Middle Fork subbasin would have a minor effect to piscivorous wildlife in the long-term with an increase in prey abundance within the subbasin.

**Coast Fork Subbasin**

There are no local operations proposed under the near-term operations measure within the Coast Fork subbasin, therefore, there would be no effects of this measure to wildlife in this subbasin.

**Mainstem Willamette River**

The primary effect within the mainstem Willamette River would be a minor long-term improvement to fish populations that provide foraging opportunities for piscivorous wildlife species such as bald eagles, river otters, great blue heron, osprey, and mergansers.

*3.9.2.5.2 Climate Change*

The climate change effects discussed in regard to the NAA (Section 3.9.2.2) are concerns for Alternative 2A as well. However, providing water quality measures, adaptive fish flows, and fish passage in several subbasins so that fish can access cooler water would support wildlife species by supporting habitat function in the form of foraging opportunities and cool water downstream of the dams. On the other hand, deep drawdowns (the deep fall drawdown at Detroit) are anticipated to exacerbate climate change effects (longer drier summers) to wildlife species and habitat. The drawdown would effectively signal to salmonid to move downstream, but the wildlife species that depend on the reservoirs as a source of water and foraging opportunities, would be left with less water (harder to access), water more prone to algal blooms (warmer temperatures), and fewer foraging opportunities (for piscivorous species) compounding stressors on these animals. Regardless, major, long-term, adverse effects to wildlife species and habitat are anticipated as a result of climate change, but the drawdown at Detroit would exacerbate these effects within the North Santiam subbasin.

*3.9.2.5.3 Alternative 2A Wildlife, Birds, and Terrestrial Habitat Effects Summary Table*

Table 3.9-25 below presents a summary of the effects to wildlife and wildlife habitat within the WVS as a result of implementation of Alternative 2A.

**Table 3.9-5. Summary of Effects for Wildlife, Birds, and Terrestrial Habitat under Alternative 2A as Compared to the Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam)**

| Subbasin | Alternative 2A |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with benefits to aquatic and wetland habitat<br>North and South Santiam rivers - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Green Peter and Detroit - drawdowns with minor effects to wildlife and wildlife habitat around the reservoirs<br>Green Peter – deep fall season drawdown with long-term moderate effects to wildlife and wildlife habitat around reservoir<br>Green Peter, Detroit, and Foster – water quality improvements with minor benefits for foraging wildlife<br>Green Peter – lamprey passage minor beneficial effects<br>Detroit and Foster- downstream fish passage with minor benefits in the form of foraging and nutrient cycling |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with benefits to aquatic and wetland habitat<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Cougar and Blue River - drawdowns with minor effects to wildlife and wildlife habitat around the reservoirs<br>Cougar - downstream fish passage with minor benefits in the form of foraging and nutrient cycling |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with benefits to aquatic and wetland habitat<br>Middle Fork Willamette - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor effects to wildlife and wildlife habitat around the reservoirs<br>Lookout Point - downstream fish passage with minor benefits in the form of foraging and nutrient cycling |
| Coast Fork of the Willamette Subbasin | Negligible change |

| Subbasin | Alternative 2A |
|---|---|
| Mainstem Willamette River | Negligible change |

#### *3.9.2.6 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

As in other action alternatives, the integrated temperature and habitat flow regime (#30a) would have negligible effects to riverine wetlands and aquatic habitat within the North Santiam, South Santiam, McKenzie, Coast Fork Willamette, Middle Fork Willamette, and Long Tom subbasins.

The primary difference between Alternatives 2A and 2B is at Cougar Dam, the diversion tunnel will be used for fish passage for Alternative 2B whereas for Alternative 2A, an FSS will be used. There could be slight differences in fish survivorship which could indirectly affect piscivorous wildlife; however, the differences in these effects are anticipated to be negligible, though there is much uncertainty at this point. In addition, there would be differences in lake levels within Cougar Reservoir at different points during the year as in Alternative 2B the spring and fall drawdowns would be down to the diversion tunnel. This would have different indirect hydrologic effects to wetlands and off-channel areas that provide wildlife habitat for amphibians and reptiles around Cougar Reservoir and downstream on the South Fork McKenzie and mainstem McKenzie River. The spring reservoir drawdown for downstream fish passage (#720) at Cougar would occur May 1 to July 1 and the deeper fall reservoir drawdowns for fish passage (#40) at Cougar (also at Green Peter which was included in Alternative 2A) would occur October 15 to December 15. The effects of the spring and fall drawdowns to the diversion tunnel at Cougar would likely include a loss of wetland habitat acreage within the reservoir. This is anticipated to have minor to moderate, long-term, adverse effects to wetland habitat and wildlife species that depend on this habitat, namely amphibians and reptiles. The spring drawdown could also create higher flows that dislodge amphibian egg masses and larvae downstream. Furthermore, higher flows in spring could result in inundation of turtle nesting areas resulting in either mortality of eggs or failure to nest depending on nest timing of individual turtles. The fall drawdown could result in mortality of eggs and hatchlings still within the nest cavity. Other effects of the drawdowns to wildlife were discussed in regard to Alternative 2A. These include increasing the distance that wildlife would need to travel to access the water's edge and potential to negatively alter wildlife habitat. These drawdown effects to wildlife species and habitat would be long-term, moderate, and adverse and would occur in the South Santiam and McKenzie subbasins.

As for Alternative 2B, augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718) are proposed to augment stream flows during the late summer and fall. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Cougar, Green Peter, and Detroit and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Fall Creek and Blue River. These measures would have negligible long-term effects to riverine wetland and aquatic habitats downstream of the dams because water levels in downstream reaches would not be measurably affected. However, within the reservoirs there would be an effect to wildlife access to the water's edge during the late summer and fall, which is typically a dry time of year. Wildlife species would have to travel slightly farther than usual. However, these slight drawdowns would not occur during the wildlife breeding season (spring), so these measures are anticipated to have minor, long-term, and recurring adverse effects to wildlife species within the Middle Fork Willamette, McKenzie, South Santiam, and North Santiam subbasins.

Alternative 2B would include providing Pacific lamprey passage and infrastructure (#52) at Green Peter; and constructing structural downstream fish passage (#392) at Detroit, Foster, and Lookout Point. As previously mentioned, downstream passage at Cougar is provided through the spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40) to the diversion tunnel. In addition, Alternative 2B measures that would improve water temperature include constructing WTC towers (#105); using ROs to discharge colder water (#166); the Foster Fish Ladder Temperature Improvement (#479); and using the spillway for surface spill in summer (#721) would improve salmonid survival. Measures included are focused on improving water quality and fish passage. This should improve lamprey populations in the South Santiam subbasin and salmonid populations in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins. Improving fish populations would provide long-term minor beneficial effects in terms of increased foraging opportunities for piscivorous wildlife species including, but not limited to, river otters, snakes, racoons, weasels, eagles, osprey, great blue herons, etc.

As compared with the NAA, conditions for terrestrial wildlife would remain status que as upland habitats would have negligible effects. Conditions for aquatic and semi-aquatic wildlife would also remain status que long-term for many species. Impacts to turtles and amphibians within the reservoirs could see a decline over the long-term.

###### *3.9.2.6.1 Near-term Operations Measure*

See Alternative 2A, Section 3.9.2.5.1, for description of effects due to the near-term operations measure.

###### *3.9.2.6.2 Climate Change*

The climate change effects discussed in regard to the NAA (Section 3.9.2.2.) are concerns for Alternative 2B as well. As with Alternative 2A, providing water quality measures, adaptive fish flows, and fish passage in several subbasins so that fish can access cooler water would support wildlife species by supporting habitat function in the form of foraging opportunities and cool water downstream of the dams. On the other hand, deep drawdowns (at Cougar and Green Peter) are anticipated to exacerbate climate change effects (longer drier summers) to wildlife species and habitat. The drawdowns would effectively signal to salmonid to move downstream, but the wildlife species that depend on the reservoirs as a source of water and foraging opportunities, would be left with less water (harder to access), prone to algal blooms (warmer temperatures), and fewer foraging opportunities compounding stressors on these animals. Regardless, major long-term adverse effects to wildlife species and habitat are anticipated as a result of climate change but the drawdowns at Cougar and Green Peter would exacerbate these effects within the McKenzie and North Santiam subbasins.

#### *3.9.2.6.3 Alternative 2B Wildlife, Birds, and Terrestrial Habitat Effects Summary Table*

Table 3.9-26 below presents a summary of the effects to wildlife and wildlife habitat within the WVS as a result of implementation of Alternative 2B.

**Table 3.9-6. Summary of Effects for Wildlife, Birds, and Terrestrial Habitat under Alternative 2B as Compared to the Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)**

| Subbasin | Alternative 2B |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with benefits to aquatic and wetland habitat<br>North and South Santiam rivers - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Green Peter and Detroit - drawdowns with minor effects to wildlife and wildlife habitat at the reservoirs<br>Green Peter – deep fall season drawdown with long-term moderate adverse effects to wildlife and wildlife habitat around reservoir<br>Green Peter, Detroit, and Foster – water quality improvements with minor benefits for foraging wildlife<br>Green Peter – lamprey passage minor beneficial effects<br>Detroit and Foster - downstream fish passage with minor benefits in the form of foraging and nutrient cycling |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with benefits to aquatic and wetland habitat<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Cougar and Blue River - drawdowns with minor effects to wildlife and wildlife habitat at the reservoirs<br>Cougar – deep spring and fall season drawdowns with long-term moderate effects to wildlife and wildlife habitat around reservoir |

| Subbasin | Alternative 2B |
|---|---|
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with benefits to aquatic and wetland habitat<br>Middle Fork Willamette - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor effects to wildlife and wildlife habitat at the reservoirs<br>Lookout Point - downstream fish passage with minor benefits in the form of foraging and nutrient cycling |
| Coast Fork of the Willamette Subbasin | Negligible change |
| Mainstem Willamette River | Negligible change |

#### *3.9.2.7 Alternative 3A – Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)*

Measures that would affect wildlife species and habitat within the WVS as part of Alternative 3A include a spring reservoir drawdown for downstream fish passage (#720) at Cougar, Detroit, and Lookout Point reservoirs (May 1 to July 1) as well as a deeper fall reservoir drawdown for fish passage (#40) at Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point reservoirs (October 15 to December 15). The spring drawdown at Lookout Point could affect northwestern pond turtles that nest at the reservoir. These turtles would have to adjust their normal nesting locations which would cause them to expend more energy in finding a new nesting location. For amphibians that breed within shallow water alcoves and at the confluences of tributaries, the spring drawdowns could lead to desiccation of egg masses and stranding of larvae. Alternately, they might nest further out into the lakebed, which would then potentially be flooded as the reservoir refills. The drawdowns would also affect other wildlife species' access to the water during these time periods. Species such as black-tailed deer, elk, raccoons, ermine, coyotes, etc. would need to travel farther to get to the water's edge and in some areas, may need to cross steep unvegetated slopes. The seasonal drawdown may cause wildlife attempting to access the water's edge to access alternative water sources in the vicinity of the reservoirs during the drawdown time periods. In addition, the drawdowns would affect wildlife species that build lodges, burrows, or dens along the water's edge such as beavers, muskrats, otters, etc. The dramatic changes in water surface elevations in these reservoirs throughout the year would flood these habitat structures at certain times of year and leave them perched, away from open water at other times. This may cause animals to build multiple habitat structures throughout the year in these locations. Increasing the distance that wildlife would need to travel to access the water's edge, potentially damaging wildlife habitat structures through water level fluctuations, and potentially impacting northwestern pond turtle nesting would have long-term, moderate, adverse effects on wildlife species within the McKenzie, North Santiam, Middle Fork Willamette, and North Santiam subbasin.

The downstream impacts of the spring reservoir drawdown for downstream fish passage and the deeper fall reservoir drawdown for fish passage could include the burying of freshwater mussel beds, the movement of non-native fish from the reservoirs to off-channel habitats which could lead to increased predation of native fish, amphibians, and turtle hatchlings. Additionally, sediment moved downstream during the deep drawdowns could reduce connectivity of off-channel habitats or degrade the quality of off-channel habitats for aquatic wildlife and vegetation. Many of these sediments could be flushed out of the off-channel habitats in subsequent high flow events.

For Alternative 3A, the integrated temperature and habitat flow regime (#30a) would have negligible effects to riverine wetlands and aquatic habitat within the North Santiam, South Santiam, McKenzie, Coast Fork Willamette, Middle Fork Willamette, and Long Tom subbasins.

In addition, augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718) are proposed to augment stream flows during the late summer and fall. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Cougar, Green Peter, and Detroit and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Fall Creek, Blue River, Cottage Grove, and Dorena. These measures would have negligible long-term effects to riverine wetland and aquatic habitats downstream of the dams because water levels in downstream reaches would not be measurably affected. However, within the reservoirs there would be an effect to wildlife access to the water's edge during the late summer and fall, which is typically a dry time of year. Wildlife species would have to travel slightly farther than usual. However, these slight drawdowns would not occur during the wildlife breeding season (spring) so these measures are anticipated to have minor, long-term, adverse effects to wildlife species within the Middle Fork Willamette, Coast Fork Willamette, McKenzie, South Santiam, and North Santiam subbasins.

Alternative 3A will also provide Pacific lamprey passage and infrastructure (#52) at Blue River, Green Peter, and Hills Creek Dams; and pass water over spillway in spring for fish passage (#714) at Big Cliff, Dexter, Fall Creek, Green Peter, and Hills Creek Dams. In addition, Alternative 3A measures that would improve water temperature include using ROs to discharge colder water (#166) and using spillway for surface spill in summer (#721) would improve salmonid survival. Fish passage and water quality measures would improve lamprey populations in the McKenzie, South Santiam, and Middle Fork Willamette subbasins and salmonid populations in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins. Improving fish populations would provide long-term, minor, beneficial effects in terms of increased foraging opportunities for piscivorous wildlife species including, but not limited to, river otters, snakes, raccoons, weasels, eagles, osprey, great blue herons, etc. that use habitat upstream of the dams in these subbasins.

As compared with the NAA, conditions for terrestrial wildlife would remain status que as upland habitats would have negligible effects. Conditions for aquatic and semi-aquatic wildlife would also remain status que long-term for many species. Impacts to turtles and amphibians within the reservoirs could see a decline over the long-term.

#### *3.9.2.7.1 Near-term Operations Measure*

See Alternative 2A, Section 3.9.2.5.1, for description of effects due to the near-term operations measure.

#### *3.9.2.7.2 Climate Change*

The climate change effects discussed in regard to the NAA (Section 3.9.2.2.) are concerns for Alternative 3A as well. Providing water quality measures, adaptive fish flows, and fish passage in several subbasins so that fish can access cooler water would support wildlife species by supporting habitat function in the form of foraging opportunities and cool water downstream of the dams. On the other hand, deep drawdowns (at Cougar, Blue River, Lookout Point, Hills Creek, Green Peter, and Detroit) are anticipated to exacerbate climate change effects (longer drier summers) to wildlife species and habitat. The drawdowns would effectively signal to salmonid to move downstream, but the wildlife species that depend on the reservoirs as a source of water and foraging opportunities, would be left with less water (harder to access), prone to algal blooms (warmer temperatures), and fewer foraging opportunities (for piscivorous species) compounding stressors on these animals. Regardless, major long-term adverse effects to wildlife species and habitat are anticipated as a result of climate change but the drawdowns would exacerbate these effects within the McKenzie, Middle Fork Willamette, South Santiam, and North Santiam subbasins.

#### *3.9.2.7.3 Alternative 3A Wildlife, Birds, and Terrestrial Habitat Effects Summary Table*

Table 3.9-27 below presents a summary of the effects to wildlife and wildlife habitat within the WVS as a result of implementation of Alternative 3A.

**Table 3.9-7. Summary of Effects for Wildlife, Birds, and Terrestrial Habitat under Alternative 3A as Compared to the Alternative 3A – Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)**

| Subbasin | Alternative 3A |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with benefits to aquatic and wetland habitat<br>North and South Santiam rivers - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Green Peter, Detroit, and Foster – water quality improvements with minor benefits for foraging wildlife |

| Subbasin | Alternative 3A |
|---|---|
| | Green Peter and Detroit - drawdowns with minor effects to wildlife and wildlife habitat around the reservoirs<br>Detroit – fall and spring drawdowns with long-term moderate effects to wildlife and wildlife habitat around reservoir<br>Green Peter – deep fall season drawdown with long-term moderate effects to wildlife and wildlife habitat around reservoir<br>Green Peter - lamprey passage with minor benefits in the form of foraging and nutrient cycling<br>Big Cliff and Green Peter - downstream fish passage with minor benefits in the form of foraging and nutrient cycling |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with benefits to aquatic and wetland habitat<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Blue River – water quality improvements with minor benefits for foraging wildlife<br>Cougar and Blue River - drawdowns with minor effects to wildlife and wildlife habitat around the reservoirs<br>Cougar – deep spring and fall season drawdowns with long-term moderate effects to wildlife and wildlife habitat at reservoir<br>Blue River – deep fall season drawdown with long-term moderate effects to wildlife and wildlife habitat at reservoir<br>Blue River - lamprey passage with minor benefits in the form of foraging and nutrient cycling |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with benefits to aquatic and wetland habitat<br>Middle Fork Willamette - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Lookout Point and Hills Creek – water quality improvements with minor benefits for foraging wildlife<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor effects to wildlife and wildlife habitat at the reservoirs<br>Lookout Point – deep spring and fall season drawdowns with long-term moderate effects to wildlife and wildlife habitat at reservoir |

| Subbasin | Alternative 3A |
| --- | --- |
| | Hills Creek – deep fall season drawdown with long-term moderate effects to wildlife and wildlife habitat at reservoir<br>Hills Creek - lamprey passage with minor benefits in the form of foraging and nutrient cycling<br>Hills Creek, Fall Creek, and Dexter – downstream fish passage with minor benefits in the form of foraging and nutrient cycling |
| Coast Fork of the Willamette Subbasin | Negligible change |
| Mainstem Willamette River | Negligible change |

#### *3.9.2.8 Alternative 3B – Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

In terms of wildlife species and habitat effects, Alternative 3B is very similar to Alternative 3A; however, one of the differences is that the spring reservoir drawdown for downstream fish passage (#720) would occur at Cougar, Green Peter, and Hills Creek reservoirs instead of Cougar, Detroit, and Lookout Point reservoirs. Therefore, the effects of spring reservoir drawdowns would be realized at those reservoirs and the McKenzie, North Santiam, and Middle Fork Willamette subbasins, where South Santiam had been included before instead of North Santiam. The spring drawdown at Hills Creek and Lookout Point could affect northwestern pond turtles that nest at the reservoir. These turtles would have to adjust their normal nesting locations which would either cause them to expend more energy in finding a new nesting location. For amphibians that breed within shallow water alcoves and at the confluences of tributaries, the spring drawdowns could lead to desiccation of egg masses and stranding of larvae. Fall drawdowns are proposed at Lookout Point, Hills Creek, Cougar, Blue River, Green Peter, and Detroit. Similar to the drawdown effects discussed as part of Alternative 3A, increasing the distance that wildlife would need to travel to access the water's edge, potentially damaging wildlife habitat structures through water level fluctuations, and potentially impacting northwestern pond turtle nesting would have long-term, moderate, adverse effects on wildlife species within the McKenzie, North Santiam, Middle Fork Willamette, and North Santiam subbasin with the implementation of Alternative 3B.

The downstream impacts of the spring reservoir drawdown for downstream fish passage and the deeper fall reservoir drawdown for fish passage could include the burying of freshwater mussel beds, the movement of non-native fish from the reservoirs to off-channel habitats which could lead to increased predation of native fish, amphibians, and turtle hatchlings. Additionally, sediment moved downstream during the deep drawdowns could reduce connectivity of off-channel habitats or degrade the quality of off-channel habitats for aquatic wildlife and vegetation. Many of these sediments could be flushed out of the off-channel habitats in subsequent high flow events.

There are also differences in terms of fish passage improvements. Alternative 3B would improve fish passage by passing water over spillway in spring for fish passage (#714) at Big Cliff, Detroit, Dexter, and Lookout Point Dams as well as through the drawdowns previously discussed. Providing Pacific lamprey passage and infrastructure (#52) will occur at Hills Creek, Blue River, and Green Peter. Alternative 3B measures that would improve water temperature include using ROs to discharge colder water (#166) and using spillway for surface spill in summer (#721) would improve salmonid survival. Improving lamprey and salmonid populations in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins would provide long-term minor beneficial effects in terms of increased foraging opportunities for piscivorous wildlife species including but not limited to river otters, snakes, raccoons, weasels, eagles, osprey, great blue herons, etc. upstream of the dams in these subbasins.

As with Alternative 3A, Alternative 3B would implement an integrated temperature and habitat flow regime (#30a) which would have negligible effects to riverine wetlands and aquatic habitat within the North Santiam, South Santiam, McKenzie, Coast Fork Willamette, Middle Fork Willamette, and Long Tom subbasins. Effects would depend on the type of water year. In low flow, high water temperature years off-channel habitats (including wetland areas) downstream of the dams could experience late-spring to early-summer flows which could inundate these areas that could impact plant growth and available nesting habitat for turtles. For years where there would be high flow, low water temperature, the flow regime could provide more connectivity of off-channel habitats which is comparable to spring flood events.

In addition, augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718) are proposed to augment stream flows during the late summer and fall. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Green Peter, and Detroit and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Fall Creek, Blue River, Cottage Grove, and Dorena. These measures would have negligible long-term effects to riverine wetland and aquatic habitats downstream of the dams because water levels in downstream reaches would not be measurably affected. However, within the reservoirs there would be an effect to wildlife access to the water's edge during the late summer and fall, which is typically a dry time of year. Wildlife species would have to travel slightly farther than usual. However, these slight drawdowns would not occur during the wildlife breeding season (spring) so these measures are anticipated to have minor, long-term, adverse effects to wildlife species within the Middle Fork Willamette, Coast Fork Willamette, McKenzie, South Santiam, and North Santiam subbasins.

As compared with the NAA, conditions for terrestrial wildlife would remain status que as upland habitats would have negligible effects. Conditions for aquatic and semi-aquatic wildlife would also remain status que long-term for many species. Impacts to turtles and amphibians within the reservoirs could see a decline over the long-term.

#### *3.9.2.8.1 Near-term Operations Measure*

See Alternative 2A, Section 3.9.2.5.1, for description of effects due to the near-term operations measure.

#### *3.9.2.8.2 Climate Change*

The climate change effects discussed in regard to the NAA (Section 3.9.2.2.) are concerns for Alternative 3B as well. Providing water quality measures, adaptive fish flows, and fish passage in several subbasins so that fish can access cooler water would support wildlife species by supporting habitat function in the form of foraging opportunities and cool water downstream of the dams. On the other hand, deep drawdowns (at Cougar, Blue River, Lookout Point, Hills Creek, Green Peter, and Detroit) are anticipated to exacerbate climate change effects (longer drier summers) to wildlife species and habitat. The drawdowns would effectively signal to salmonid to move downstream, but the wildlife species that depend on the reservoirs as a source of water and foraging opportunities, would be left with less water (harder to access), prone to algal blooms (warmer temperatures), and fewer foraging opportunities (for piscivorous species) compounding stressors on these animals. Regardless, major long-term adverse effects to wildlife species and habitat are anticipated as a result of climate change but the drawdowns would exacerbate these effects within the McKenzie, Middle Fork Willamette, South Santiam, and North Santiam subbasins.

#### *3.9.2.8.3 Alternative 3B Wildlife, Birds, and Terrestrial Habitat Effects Summary Table*

Table 3.9-28 below presents a summary of the effects to wildlife and wildlife habitat within the WVS as a result of implementation of Alternative 3B.

**Table 3.9-8. Summary of Effects for Wildlife, Birds, and Terrestrial Habitat under Alternative 3B as Compared to the Alternative 3B – Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)**

| Subbasin | Alternative 3B |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with benefits to aquatic and wetland habitat<br>North and South Santiam rivers - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Green Peter, Detroit, and Foster – water quality improvements with minor benefits for foraging wildlife<br>Green Peter and Detroit - drawdowns with minor effects to wildlife and wildlife habitat at the reservoirs<br>Green Peter – deep fall and spring season drawdown with long-term moderate effects to wildlife and wildlife habitat at reservoir |

| Subbasin | Alternative 3B |
|---|---|
| | Detroit – deep fall season drawdown with long-term moderate effects to wildlife and wildlife habitat at reservoir<br>Detroit - downstream fish passage with minor benefits in the form of foraging and nutrient cycling<br>Green Peter – lamprey passage with minor benefits in the form of foraging and nutrient cycling |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with benefits to aquatic and wetland habitat<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Blue River – water quality improvements with minor benefits for foraging wildlife<br>Blue River - drawdown with minor effects to wildlife and wildlife habitat at the reservoirs<br>Cougar – deep spring and fall season drawdowns (down to the diversion tunnel) with long-term moderate effects to wildlife and wildlife habitat at reservoir<br>Blue River – deep fall season drawdown with long-term moderate effects to wildlife and wildlife habitat at reservoir<br>Blue River – lamprey passage with minor benefits in the form of foraging and nutrient cycling |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with benefits to aquatic and wetland habitat<br>Middle Fork Willamette - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Lookout Point and Hills Creek – water quality improvements with minor benefits for foraging wildlife<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor effects to wildlife and wildlife habitat at the reservoirs<br>Hills Creek – deep spring and fall season drawdowns with long-term moderate effects to wildlife and wildlife habitat at reservoir<br>Lookout Point – deep fall season drawdown with long-term moderate effects to wildlife and wildlife habitat at reservoir<br>Hills Creek – lamprey passage with minor benefits in the form of foraging and nutrient cycling |

| Subbasin | Alternative 3B |
|---|---|
| | Dexter and Lookout Point – downstream fish passage with minor benefits in the form of foraging and nutrient cycling |
| Coast Fork of the Willamette Subbasin | Cottage Grove and Dorena – drawdowns with minor effects to wildlife and wildlife habitat at the reservoirs |
| Mainstem Willamette River | Negligible change |

#### *3.9.2.9 Alternative 4 – Improve Fish Passage with Structures-Based Approach*

Effects to wildlife species and habitat for Alternative 4 would be similar to that of Alternative 1 since these both intend to meet the purpose and need without spring or fall drawdowns. This alternative would include providing Pacific lamprey passage and infrastructure (#52) at Hills Creek; restoring upstream and downstream passage at drop structures (#639) within the Long Tom River downstream of Fern Ridge; and constructing structural downstream fish passage (#392) at Cougar, Detroit, Foster, Hills Creek, and Lookout Point (fish collection around Dexter). In addition, Alternative 4 measures that would improve salmonid survival by improving TDG levels include structural improvements to reduce TDG (#174); and by improving water temperature include constructing WTC towers (#105); using ROs to discharge colder water (#166); the Foster Fish Ladder Temperature Improvement (#479); and using the spillway for surface spill in summer (#721). Measures included are focused on improving water quality and fish passage. This would improve lamprey populations in the Middle Willamette subbasin and salmonid populations in the North Santiam, South Santiam, McKenzie, Long Tom, and Middle Willamette Fork subbasins. Improving fish populations would provide long-term, minor, beneficial effects in terms of increased foraging opportunities for piscivorous wildlife species including, but not limited to, river otters, snakes, raccoons, weasels, eagles, osprey, great blue herons, etc. upstream of the dams in these subbasins.

Alternative 4 would implement an integrated temperature and habitat flow regime (#30a), which would have negligible effects to riverine wetlands and aquatic habitat within the North Santiam, South Santiam, McKenzie, Coast Fork Willamette, Middle Fork Willamette, and Long Tom subbasins.

Augmenting instream flows by using the power pool (#304) and augmenting instream flows by using the inactive pool (#718) are proposed to augment stream flows during the late summer and fall. Augmenting instream flows by using the power pool (#304) is proposed for Lookout Point, Hills Creek, Cougar, Green Peter, and Detroit and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Augmenting instream flows by using the inactive pool (#718) is proposed for Fall Creek, Blue River, Cottage Grove, and Dorena. These measures would have negligible long-term effects to riverine wetland and aquatic habitats downstream of the dams because water levels in downstream reaches would not be measurably affected. However, within the reservoirs there would be an effect to wildlife access to the water’s edge during the late summer and fall, which is typically a dry time of year. Wildlife species would have to travel slightly farther than usual. However, these slight drawdowns would not occur during the wildlife breeding season (spring) so these measures are anticipated to have minor long-term adverse effects to wildlife species within the Middle Fork Willamette, Coast Fork Willamette, McKenzie, South Santiam, and North Santiam subbasins.

As compared with the NAA, conditions for terrestrial wildlife would remain status que as upland habitats would have negligible effects. Conditions for aquatic and semi-aquatic wildlife would also remain status que long-term for many species. Impacts to turtles and amphibians within the reservoirs could see a decline over the long-term.

#### *3.9.2.9.1 Near-term Operations Measure*

See Alternative 2A, Section 3.9.2.5.1, for description of effects due to the near-term operations measure.

#### *3.9.2.9.2 Climate Change*

The climate change effects discussed in regard to the NAA (Section 3.9.2.2.) are concerns for Alternative 4 as well. However, meeting water storage objectives while also providing fish passage and water quality benefits to wildlife and habitat by providing hydrologic support for aquatic and wetland habitats, improving instream water quality to support aquatic species, and increasing foraging opportunities for wildlife species upstream of the dams is anticipated to support wildlife species and habitat to the extent possible while these regional changes occur. Alternative 4 would not avoid the effects of climate change to wildlife and associated habitats but would potentially decrease the effects. However, major long-term adverse effects to wildlife species and habitat as a result of climate change would still be anticipated.

#### *3.9.2.9.3 Alternative 4 Wildlife, Birds, and Terrestrial Habitat Effects Summary Table*

Table 3.9-29 below presents a summary of the effects to wildlife and wildlife habitat within the WVS as a result of implementation of Alternative 4.

**Table 3.9-9. Summary of Effects for Wildlife, Birds, and Terrestrial Habitat under Alternative 4 as Compared to the Alternative 4 – Improve Fish Passage with Structures-Based Approach**

| Subbasin | Alternative 4 |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with benefits to aquatic and wetland habitat<br>North and South Santiam rivers - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Green Peter, Detroit, Foster – water quality improvements with minor benefits for foraging wildlife<br>Green Peter and Detroit - drawdowns with minor effects to wildlife and wildlife habitat at the reservoirs |

| Subbasin | Alternative 4 |
|---|---|
| | Detroit and Foster – downstream passage with minor benefits in the form of foraging and nutrient cycling<br>Detroit – WTC tower with minor beneficial effects |
| Long Tom Subbasin | Fern Ridge – upstream and downstream passage with minor benefits in the form of foraging and nutrient cycling |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with benefits to aquatic and wetland habitat<br>Cougar – water quality improvements with minor benefits for foraging wildlife<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible effects to streamside aquatic and wetland habitat<br>Cougar and Blue River - drawdowns with minor effects to wildlife and wildlife habitat around the reservoirs<br>Cougar – downstream passage with minor benefits in the form of foraging and nutrient cycling |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with benefits to aquatic and wetland habitat<br>Middle Fork Willamette - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Dexter, Lookout Point, and Hills Creek – water quality improvements with minor benefits for foraging wildlife<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor effects to wildlife and wildlife habitat at the reservoirs<br>Hills Creek – lamprey passage with minor benefits in the form of foraging and nutrient cycling<br>Hills Creek and Lookout Point – downstream passage with minor benefits in the form of foraging and nutrient cycling |
| Coast Fork of the Willamette Subbasin | Cottage Grove and Dorena – drawdowns with minor effects to wildlife and wildlife habitat around the reservoirs |
| Mainstem Willamette River | Negligible change |

#### *3.9.2.10 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 5 is nearly identical to Alternative 2B. However, similar to Alternative 2B, Alternative 5 stream flows will be adapted to fish survival and passage needs except that the integrated temperature and habitat flow regime (#30a) has been replaced by the refined integrated temperature and habitat flow regime (#30b). Neither of these measures would have a measurable effect to the frequency of inundation and therefore, would have negligible effects to aquatic and riverine wetland habitat within the downstream reaches of the North Santiam, South Santiam, McKenzie, Coast Fork Willamette, and Middle Fork Willamette subbasins.

In terms of wildlife and wildlife habitat effects around the reservoirs, the deep spring season drawdown at Cougar would occur May 1 to July 1 and the deep fall season drawdown at Cougar and Green Peter would occur October 15 to December 15. The effects of the spring and fall drawdowns to the diversion tunnel at Cougar would likely include a loss of wetland habitat acreage. This is anticipated to have moderate long-term adverse effects to wetland habitat and wildlife species that depend on this habitat, namely amphibians and reptiles. Other effects of the drawdowns to wildlife were discussed in regard to Alternative 2A. These include increasing the distance that wildlife would need to travel to access the water's edge and potentially damaging wildlife habitat structures through water level fluctuations. These drawdown effects to wildlife species and habitat would be long-term, moderate, and adverse and would occur in the South Santiam and McKenzie subbasins.

Like Alternatives 2A and 2B, Measures 304 and 718 are proposed to augment stream flows during the late summer and fall. Measure 304 is proposed for Lookout Point, Hills Creek, Green Peter, and Detroit and would allow these projects to drawdown below the power pool and respective rule curves for these projects. Measure 718 is proposed for Fall Creek and Blue River. These measures would have negligible long-term effects to riverine wetland and aquatic habitats downstream of the dams because water levels in downstream reaches would not be measurably affected. However, within the reservoirs there would be an effect to wildlife access to the water's edge during the late summer and fall, which is typically a dry time of year. Wildlife species would have to travel slightly farther than usual. However, these slight drawdowns would not occur during the wildlife breeding season (spring) so these measures are anticipated to have minor long-term adverse effects to wildlife species within the Middle Fork Willamette, McKenzie, South Santiam, and North Santiam subbasins.

Alternative 5 would include adding lamprey passage at Green Peter (Measure 52); and downstream passage structures (Measure 392) at Detroit, Foster, and Lookout Point. As previously mentioned, downstream passage at Cougar is provided through the spring and fall drawdowns to the diversion tunnel (Measures 40 and 720). In addition, Alternative 5 measures that would improve water temperature (Measures 105, 166, 479, 721) would improve salmonid survival. Measures included are focused on improving water quality and fish passage. This should improve lamprey populations in the South Santiam subbasin and salmonid populations in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins. Improving fish populations would provide long-term minor beneficial effects in terms of increased foraging opportunities for piscivorous wildlife species including, but not limited to, river otters, snakes, racoons, weasels, eagles, osprey, great blue herons, etc.

As compared with the NAA, conditions for terrestrial wildlife would remain status que as upland habitats would have negligible effects. Conditions for aquatic and semi-aquatic wildlife would also remain status que long-term for many species. Impacts to turtles and amphibians within the reservoirs could see a decline over the long-term.

*3.9.2.10.1 Near-term Operations Measure*

See Alternative 2A, Section 3.9.2.5.1, for description of effects due to the near-term operations measure.

*3.9.2.10.2 Climate Change*

The climate change effects discussed in regard to the NAA (Section 3.9.2.2.) are concerns for Alternative 5 as well. As with Alternative 2A and 2B, providing water quality measures, adaptive fish flows, and fish passage in several subbasins so that fish can access cooler water would support wildlife species by supporting habitat function in the form of foraging opportunities and cool water downstream of the dams. On the other hand, deep drawdowns (at Cougar and Green Peter) are anticipated to exacerbate climate change effects (longer drier summers) to wildlife species and habitat. The drawdowns would effectively signal to salmonid to move downstream, but the wildlife species that depend on the reservoirs as a source of water and foraging opportunities, would be left with less water (harder to access), prone to algal blooms (warmer temperatures), and fewer foraging opportunities (for piscivorous species) compounding stressors on these animals. Regardless, major long-term adverse effects to wildlife species and habitat are anticipated as a result of climate change but the drawdowns at Cougar and Green Peter would exacerbate these effects within the McKenzie and North Santiam subbasins.

*3.9.2.10.3 Alternative 5 Wildlife, Birds, and Terrestrial Habitat Effects Summary Table*

Table 3.9-30 below presents a summary of the effects to wildlife and wildlife habitat within the WVS as a result of implementation of Alternative 5.

**Table 3.9-10. Summary of Effects for Wildlife, Birds, and Terrestrial Habitat under Alternative 5 as Compared to the Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)**

| Subbasin | Alternative 5 |
|---|---|
| Santiam Subbasin | North and South Santiam rivers - gravel augmentation downstream of Big Cliff and Foster Dams with benefits to aquatic and wetland habitat<br>North and South Santiam rivers - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Green Peter and Detroit - drawdowns with minor hydrological effects to wildlife and wildlife habitat at the reservoirs<br>Green Peter – deep fall season drawdown with long-term moderate effects to wildlife and wildlife habitat around reservoir<br>Green Peter, Detroit, and Foster – water quality improvements with minor benefits for foraging wildlife<br>Green Peter – lamprey passage minor beneficial effects<br>Detroit and Foster - downstream fish passage with minor benefits in the form of foraging and nutrient cycling |
| Long Tom Subbasin | Negligible change |
| McKenzie Subbasin | South Fork McKenzie and Blue rivers - gravel augmentation downstream of Cougar and Blue River Dams with benefits to aquatic and wetland habitat<br>South Fork McKenzie and Blue rivers - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Blue River - drawdowns with minor effects to wildlife and wildlife habitat at the reservoirs<br>Cougar – deep spring and fall season drawdowns with long-term moderate effects to wildlife and wildlife habitat around reservoir |
| Middle Fork of the Willamette Subbasin | Middle Fork Willamette - gravel augmentation downstream of WVS dams with benefits to aquatic and wetland habitat<br>Middle Fork Willamette - minor decreases to downstream flows with negligible effects to aquatic and wetland habitat<br>Lookout Point, Hills Creek, and Fall Creek - drawdowns with minor effects to wildlife and wildlife habitat at the reservoirs<br>Lookout Point - downstream fish passage with minor benefits in the form of foraging and nutrient cycling |
| Coast Fork of the Willamette Subbasin | Negligible change |

| Subbasin | Alternative 5 |
| --- | --- |
| Mainstem Willamette River | Negligible change |

## 3.10 AIR QUALITY

Air quality is the measure of the atmospheric concentration of defined pollutants in a specific area. Air quality is affected by pollutant emission sources, as well as the movement of pollutants in the air via wind and other weather patterns. An air pollutant is any substance in the air that can cause harm to humans or the environment. Pollutants may be natural or human-made and may take the form of solid particles, liquid droplets, or gases. Natural sources of air pollution include smoke from wildfires, dust, and wind erosion. Human-made sources of air pollution include emissions from vehicles; dust from unpaved roads or construction sites; and smoke from human-caused fires.

The area of analysis for air quality are the USACE project locations within three counties of the Oregon's Willamette Valley: Lane, Linn, and Marion Counties. Within these counties, USACE projects currently include thirteen dams and reservoirs, five adult fish facilities (AFF), five fish hatcheries, and trap-and-haul fish trucking operations that transport fish above and below existing reservoirs. Air quality would primarily be affected by air emissions generated from diesel trucks during fish trucking operations, and diesel-powered generator usage at project locations. Air quality would also be affected by construction or maintenance activities including vehicles, machinery, and other heavy equipment, and fugitive dust emissions from reservoir drawdowns due to exposure of previously submerged sediments. This section provides a discussion of the sources of air emissions and the regulatory framework as it applies to the USACE projects within the WVS.

### 3.10.1 USACE Air Emissions

This section addresses the USACE projects and activities that generate air emissions within the WVS. It also describes the impact of those air emissions, specifically diesel emissions, and the federal and state programs in place to help reduce diesel emissions.

#### *3.10.1.1 Sources of Air Emissions within USACE Projects*

USACE projects and vehicles generate air emissions through the operation and maintenance of the WVS. The two primary sources of air emissions within the WVS are diesel generator usage at various project locations and trucking fish during trap-and-haul operations using light- and medium-duty diesel trucks. Facilities use diesel generators to supply electricity to heat and cool their buildings and equipment, or to power equipment and machinery needed for operation. Emergency diesel powered generators are located at all dams and hatcheries and are individually operated less than 50 hours per year. Trap-and-haul operations utilize light- and medium-duty trucks to transport fish, and generate air emissions through internal combustion of the truck's diesel engine. Construction or maintenance activities also generate air emissions via the vehicles, machinery, and other types of equipment used; however, these emissions are limited and specifically pertain to each individual construction project as they occur. Table 3.10-1 provides a general summary table of each USACE project in each county. Overall, fish trucking accounts for nearly 92,000 miles worth of diesel fuel emissions, while 22 diesel powered generators account for additional diesel air emissions.

**Table 3.10-1. USACE Projects Pertaining to Air Quality**

| Dam and Reservoir | AFF | Hatchery | Trap-and-Haul Routes | Fish Trucking Mileage Per Year | Emergency Diesel Generators |
|---|---|---|---|---|---|
| **Lane County** | | | | | |
| Cougar | Cougar Adult Fish Collection Facility | None | 30-mile round trip | 8,294 | 2 |
| Dexter | Dexter Adult Fish Facility | None | 30-, 70-, 80-, and 100-mile round trips | 23,040 | 1 |
| Hills Creek | None | Willamette Fish Hatchery | None | 7,680 | 2 |
| Fall Creek | Fall Creek Adult Fish Facility | None | 18-mile round trip | 4,608 | 2 |
| Blue River | None | Leaburg Hatchery[1]; McKenzie Hatchery[2] | None | 4,352 | 2 |
| Lookout Point | None | None | None | 20,915 | 2 |
| Dorena | None | None | None | None | 1 |
| Cottage Grove | None | None | None | None | 1 |
| Fern Ridge | None | None | None | None | 1 |
| **Linn County** | | | | | |
| Foster | Foster Dam Adult Fish Facility | South Santiam Fish Hatchery | 40- and 50-mile round trip | 4,480 | 2 |
| Green Peter | None | Marion Forks Hatchery[3] | None | 2,560 | 2 |
| **Marion County** | | | | | |
| Big Cliff | Minto Adult Fish Facility | None | 40- and 60-mile round trip | 12,416 | 2 |
| Detroit | None | None | None | 3,635 | 2 |
| **TOTAL** | | | | **91,980** | **22** |

[1] Leaburg Hatchery is approximately 19 miles away from Blue River Dam.

[2] McKenzie Hatchery is approximately 20 miles away from Blue River Dam.

[3] Marion Forks Hatchery is approximately 60 miles from Green Peter Dam. This is the closest dam to the facility within Linn County.

### *3.10.1.2 Diesel Air Emissions*

Diesel is the dominant fuel used by the commercial transportation sector because it offers fuel economy, power, and durability. In the United States, approximately 80 percent of all freight is moved by diesel engines, while most non-road equipment used in construction, agriculture, marine, and locomotive sectors are powered by diesel. However, diesel engines emit large amounts of nitrogen oxides, particulate matter (in particular $PM_{2.5}$), carbon, and other toxic air pollutants. Diesel particulate matter is linked to a number of serious health problems including aggravating asthma, heart and lung disease, cancer, and premature mortality. In 2012, diesel exhaust was classified as a known carcinogen to humans based on sufficient evidence that exposure to diesel engine exhaust is associated with increased lung cancer risk. Diesel exhaust also has environmental significance as a global warming contributor due to black carbon particulate, about 70 percent of the particulate emitted by a diesel engine. Black carbon only lasts in the atmosphere for a few weeks to months, but is second only to carbon dioxide as a potent climate change forcing agent. Diesel engines are the largest source of black carbon in North America (ODEQ No Date-f).

Figure 3.10-1 shows that in Oregon, over half of all diesel particulate emissions are from on-road vehicles, such as trucks, buses, and other traffic; 30 percent of diesel particulate matter is generated from non-road vehicles, such as construction equipment; and 14 percent is comprised of trains, ships, and generators (ODEQ No Date-j). USACE projects within the WVS would contribute to all categories of diesel particulate emissions under the Proposed Action and alternatives.

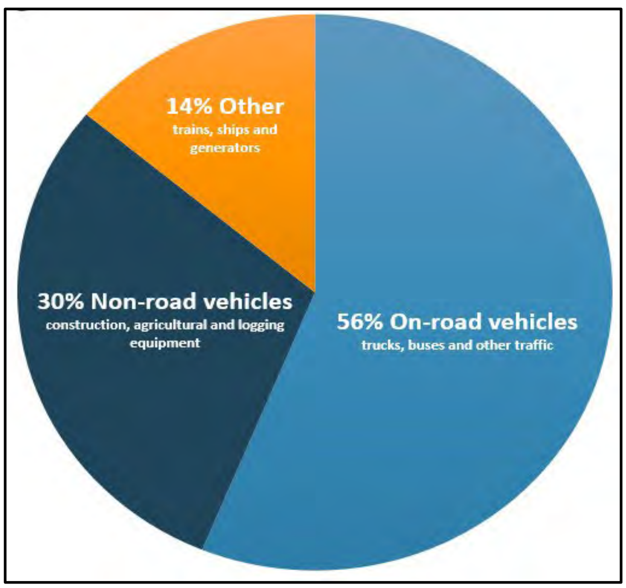



**Figure 3.10-1. Oregon Statewide Diesel Particulate Matter Emissions**

Source: ODEQ No Date-j

#### *3.10.1.3 Construction Activities and Fugitive Emissions*

Construction activities such as bulldozing, hauling, and construction vehicle travel utilize diesel equipment to provide the power needed for almost all construction activities. Environmental Protection Agency (EPA) regulations apply to new engines, while older diesel engines can remain in operation for 30 years or more. EPA offers funding, as appropriated annually by Congress, for projects that reduce emissions from existing diesel engines. EPA's *Clean Construction* provides information on strategies for reducing emissions from older engines, including idle-reduction practices that save money and fuel while reducing emissions (EPA 2021a). Portland, OR adopted the *Clean Air Construction* contracting standard in 2018, which is an initiative that reduces diesel emissions related to government-funded construction projects. Since then, Multnomah and Washington counties and Portland Metro have each adopted identical standards, and the Oregon Department of Environmental Quality (ODEQ) continues to offer technical assistance during implementation (ODEQ No Date-b).

Construction activities and reservoir drawdowns can also produce fugitive dust emissions. Fugitive dust is a type of particulate matter that becomes airborne by wind or other similar forces (EPA 2021b). This can become an issue while operating or driving on unpaved roads or during reservoir drawdowns due to exposed sediments. Oregon Administrative Rules (OAR) 340-208-0210 provides the requirements for fugitive emissions, which stipulates that no person may cause or permit any materials to be handled or transported; any building or road to be used, constructed, altered, repaired, or demolished; or any equipment to be operated – without taking reasonable precautions to prevent particulate matter from becoming airborne. Precautions may include but are not limited to using water or chemicals for dust control during demolition or construction of buildings or structures, the grading of roads, or the clearing of lands; covering open bodied trucks transporting materials likely to become airborne; and full or partial enclosure of material stockpiles to prevent particulate matter from becoming airborne. If fugitive particulate emissions escape the containment source, ODEQ may order the owner or operator to abate the emissions, including the development of a fugitive emission control plan (OregonLaws 2021).

#### *3.10.1.4 Oregon Diesel Reduction Programs*

To reduce diesel emissions in Oregon, ODEQ provides grants and programs to incentivize businesses, governments, and equipment owners to replace older and more polluting diesel engines with new, cleaner technologies and exhaust control retrofits. The Diesel Emissions Mitigation Fund is a program that provides $8 million to public, private, and tribal diesel equipment owners to replace their current diesel vehicles or equipment with equivalent, cleaner burning engines or power sources (ODEQ No Date-e).

The 2019 Oregon Legislature addressed concerns regarding significant pollution from older on-road diesel engines by passing House Bill (HB) 2007 to reduce diesel emissions across the state. Among other directives, HB 2007 requires ODEQ to establish retrofit technologies for diesel engines that power certain on-road vehicles and the process for issuing a certificate of compliance. The two vehicle weight classifications categorized in HB 2007 include medium-duty vehicles, such as certain box trucks and flatbed or service trucks, and heavy-duty vehicles, such as tractor-trailer trucks (ODEQ No Date-c). In addition, Oregon Governor Kate Brown signed a Memorandum of Understanding (MOU) in 2020, which committed Oregon to work towards the goal of 100% of all new medium- and heavy-duty vehicles sales to be zero emissions by 2050. Emissions from medium- and heavy-duty vehicles, such as large pickup trucks, vans, delivery trucks, and long-haul delivery trucks are among the fastest growing source of greenhouse gases. The MOU includes a commitment to identifying barriers and proposing solutions to support widespread adoption of these vehicles (ODEQ No Date-h).

### 3.10.2 Regulatory Framework

This section addresses the federal and state regulations regarding air quality. It includes a discussion of current air quality statuses within each county and any applicable permits pertaining to the Proposed Action and alternatives.

#### *3.10.2.1 National Ambient Air Quality Standards*

The Clean Air Act (CAA), as amended, assigns the EPA responsibility to establish National Ambient Air Quality Standards (NAAQS) (40 C.F.R. Part 50) for six principal pollutants that can be harmful to public health and the environment, for additional information see Chapter 7. These six principal pollutants include particulate matter (PM; measured in two size categories: less than or equal to 10 microns in diameter [$PM_{10}$]; and less than or equal to 2.5 microns in diameter [$PM_{2.5}$]); sulfur dioxide ($SO_2$); carbon monoxide (CO); nitrogen dioxide ($NO_2$); ozone ($O_3$); and lead (Pb).

The CAA identifies two types of NAAQSs: primary standards that provide public health protection and safeguards the health of sensitive populations such as asthmatics, children, and the elderly; and secondary standards that provide public welfare protection against decreased visibility and damage to animals, crops, vegetation, and buildings (EPA 2021c). Short-term NAAQS (1-, 8-, and 24-hour periods) have been established for pollutants that contribute to acute health effects. In contrast, long-term NAAQS (annual period) have been established for pollutants contributing to chronic health effects. These air quality standards are summarized in Table 3.10-2 below.

**Table 3.10-2. National Ambient Air Quality Standards**

| Pollutant | Primary/Secondary | Averaging Time | Level* | Form |
|---|---|---|---|---|
| Carbon Monoxide (CO) | primary | 8 hours | 9 ppm | Not to be exceeded more than once per year |
| | | 1 hour | 35 ppm | |
| Lead (Pb) | primary and secondary | Rolling 3-month average | 0.5 $\mu g/m^3$ | Not to be exceeded |
| Nitrogen Dioxide ($NO_2$) | primary | 1 hour | 100 ppb | 98th percentile of 1-hour daily maximum concentrations, |

| Pollutant | | Primary/Secondary | Averaging Time | Level* | Form |
|---|---|---|---|---|---|
| | | | | | averaged over 3 years |
| | | primary and secondary | 1 year | 53 ppb | Annual Mean |
| Ozone ($O_3$) | | primary and secondary | 8 hours | 0.070 ppm | Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years |
| Particle Pollution (PM) | $PM_{2.5}$ | primary | 1 year | 12.0 µg/m$^3$ | Annual mean, averaged over 3 years |
| | | secondary | 1 year | 15.0 µg/m$^3$ | Annual mean, averaged over 3 years |
| | | primary and secondary | 24 hours | 35 µg/m$^3$ | 98$^{th}$ percentile, averaged over 3 years |
| | $PM_{10}$ | primary and secondary | 24 hours | 150 µg/m$^3$ | Not to be exceeded more than once per year on average over 3 years |
| Sulfur Dioxide ($SO_2$) | | primary | 1 hour | 75 ppb | 99$^{th}$ percentile of 1-hour daily maximum concentrations, averaged over 3 years |
| | | secondary | 3 hours | 0.5 ppm | Not to be exceeded more than once per year |

Source: EPA 2021c

*Units of measure for the standards are parts per million (ppm) by volume, parts per billion (ppb) by volume, and micrograms per cubic meter of air (µg/m$^3$).

Federal regulations designate areas with pollution levels below the NAAQS as attainment areas, and areas with pollution levels above the NAAQS and in violation of these standards as nonattainment areas. For nonattainment areas, states must develop a State Implementation Plan (SIP) that details the path to attainment and maintain the NAAQS (EPA 2021d). If an area was in nonattainment, but now attains the standard and has an approved plan to maintain the standard, it is designated a maintenance area. All states in the Pacific Northwest, including Oregon, have EPA-approved SIPs. The Oregon SIP (40 CFR Subpart MM) helps to attain and maintain air quality in the Willamette Valley. A state’s SIP must also contain control measures for emissions that cross state lines.

#### *3.10.2.2 State Ambient Air Quality Standards*

Each state has the authority to adopt standards stricter than those established under the federal program. The State of Oregon's air quality laws are codified in the Oregon Revised Statutes, Chapter 468A, and its corresponding regulations are in the OAR, Chapter 340. ODEQ operates the ambient monitoring network for the entire state except for Lane County, which is operated by the Lane Regional Air Protection Agency (LRAPA). The EPA has delegated most implementation requirements to the ODEQ except in Lane County, where the LRAPA has primary jurisdiction. The EPA retains oversight of Oregon and regularly audits air quality management by ODEQ to ensure that federal requirements are being met. Tribal lands are sovereign and do not fall under ODEQ or LRAPA jurisdiction, although several tribes operate their own monitoring networks (EPA 2008).

The ambient air quality standards for the State of Oregon are listed in OAR 340-202-0050 through 340-202-0130. These state standards are an established concentration, exposure time, and frequency of occurrence of an air contaminant or multiple contaminants in the ambient air that must not be exceeded, as displayed in Table 3.10-3. These standards are included in the State of Oregon Clean Air Act Implementation Plan that the Oregon Environmental Quality Commission adopted under OAR 340-200-0040 (Oregon Secretary of State 2022).

**Table 3.10-3. Oregon Ambient Air Quality Standards**

| Pollutant | | Averaging Time | Level* | Form |
|---|---|---|---|---|
| Carbon Monoxide (CO) | | Same as NAAQS | | |
| Lead (Pb) | | Rolling 3-month average | 0.15 µg/m$^3$ | Not to be exceeded over a 3-year period |
| Nitrogen Dioxide ($NO_2$) | | Same as NAAQS (Table 3.10-2) | | |
| Ozone ($O_3$) | | 8 hours | 0.070 ppm | Annual fourth-highest daily maximum 8-hour concentration |
| Particle Pollution (PM) | $PM_{2.5}$ | Same as NAAQS (Table 3.10-2) | | |
| | $PM_{10}$ | Same as NAAQS (Table 3.10-2) | | |
| Sulfur Dioxide ($SO_2$) | | 1 hour | 0.075 ppm | 99$^{th}$ percentile of 1-hour daily maximum concentration, averaged over 3 years |
| | | 3 hours | 0.50 ppm | Not to be exceeded more than once per year |
| | | 24 hours | 0.10 ppm | Not to be exceeded more than once per year |
| | | 1 year | 0.02 ppm | Annual mean |
| Particle Fallout | | 1 month | 3.5 g/m$^2$ | In industrial areas |
| | | 1 month | 5 g/m$^2$ | In residential and commercial areas; in industrial areas if visual observations show the presence of wood waste/soot and the volatile fraction of the sample > 70% |

| Pollutant | Averaging Time | Level* | Form |
|---|---|---|---|
| | 1 month | 10 $g/m^2$ | In residential and commercial areas if visual observations show the presence of wood waste/soot and the volatile fraction of the sample > 70% |

Source: Oregon Secretary of State 2022

*Units of measure for the standards are parts per million (ppm) by volume, micrograms per cubic meter of air ($\mu g/m^3$), and grams per square meter of air ($g/m^2$).

### *3.10.2.3 Attainment Status in Lane, Linn, and Marion counties*

Lane, Linn, and Marion counties generally meet the NAAQS, which translates to relatively good air quality throughout the area, as geographically represented in Figure 3.10-2 (ODEQ No Date-g and ODEQ No Date-i). Linn County meets all NAAQS. Marion County meets all NAAQS, but contains one maintenance area in the Greater Salem-Kaiser Area for CO. This maintenance area is located 34 miles away from Big Cliff Dam. The county maintenance plan for CO is titled the "Salem-Kaiser Area Limited Maintenance Plan". Lane County meets all NAAQS, but contains one nonattainment area in Oakridge for $PM_{2.5}$ and $PM_{10}$. This nonattainment area contains the Willamette Fish Hatchery, and is located 1.8 miles away from Hills Creek Dam. ODEQ and the LRAPA have petitioned the EPA to concur with its determination that 2020 data for $PM_{2.5}$ and $PM_{10}$ from September 11 to September 16 should be declared an exceptional event and excluded from the 2020 dataset for NAAQS compliance. Exceptionally high values for $PM_{2.5}$ and $PM_{10}$ during this period were a result of multiple wildfires, including the Holiday Farm and Thielsen wildfires (ODEQ 2021a and ODEQ 2021b). Lane County also contains one maintenance area in the Greater Eugene-Springfield Area for $PM_{10}$. This maintenance area is located 4 miles away from Fern Ridge Dam and four miles away from Dexter and Fall Creek Dams. The county maintenance plan is called "Eugene-Springfield Urban Growth Area". Therefore, while these counties contain nonattainment and maintenance areas, none of the USACE project locations are located within confirmed nonattainment or maintenance areas.

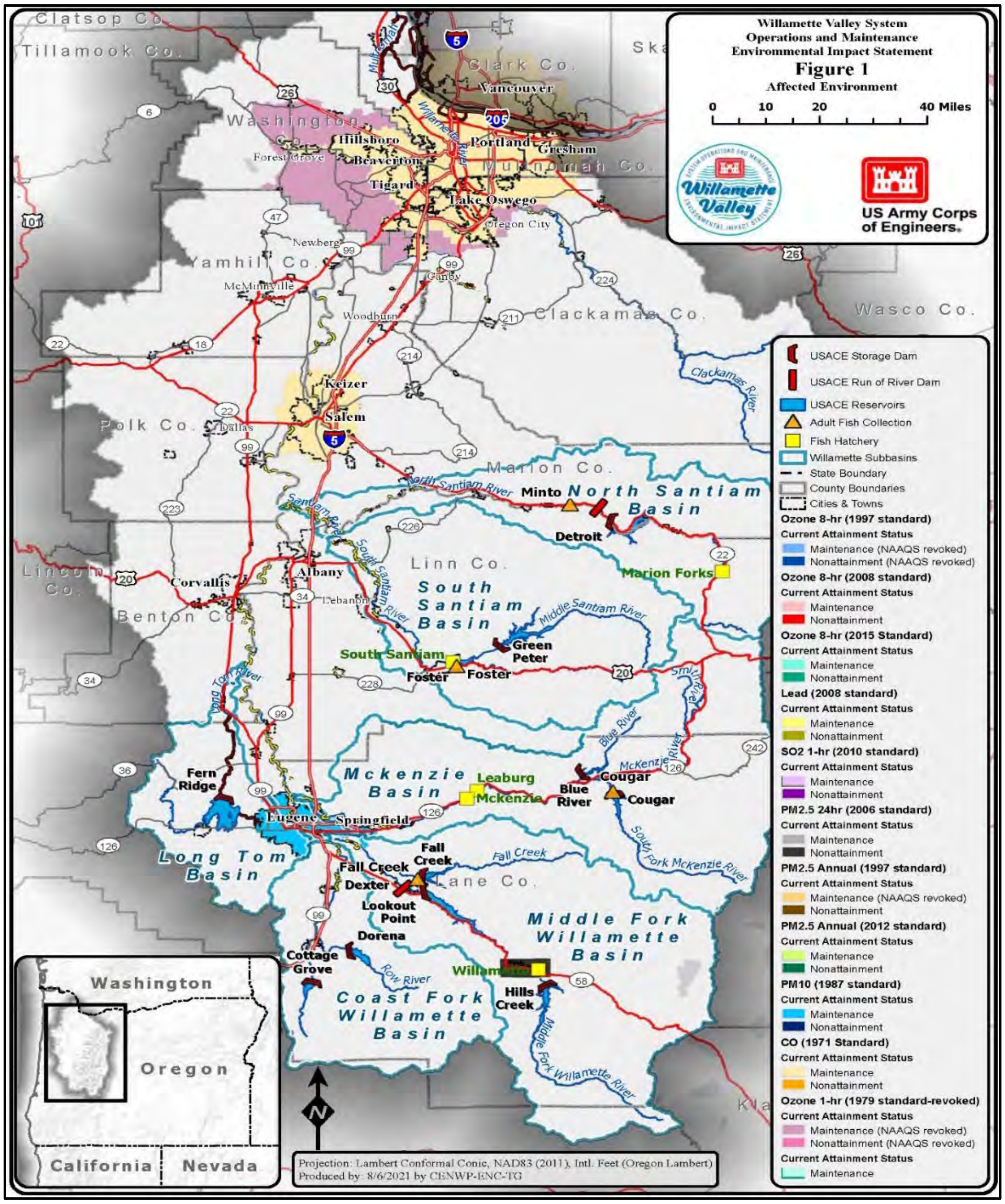



**Figure 3.10-2. Attainment, Nonattainment, and Maintenance Areas in the Willamette Valley System**

### *3.10.2.4 CAA General Conformity for Federal Actions*

Section 176(c)(1) of the CAA requires Federal agencies to assure that their actions conform to applicable implementation plans for achieving and maintaining the NAAQS for criteria pollutants, which include sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and particulate matter. For there to be conformity, a Federal action must not contribute to new violations of standards for ambient air quality, increase the frequency or severity of existing violations, or delay timely attainment of standards in the area of concern. This applies to emissions of criteria air pollutants that would occur in locations designated as nonattainment or maintenance areas for the emitted pollutants (DOE 2000).

The first phase of the general conformity requirements is the conformity review process, which evaluates whether the conformity regulations would apply to an action and whether a determination is needed. While the three counties contain two maintenance areas and one nonattainment area, none of the USACE project locations are situated within any of these areas. For this reason, a general conformity analysis is not required and may be dismissed from further discussion.

#### *3.10.2.5 Reciprocating Internal Combustion Engines (RICE)*

RICEs are combustion engines that use pistons alternatively moving back and forth to convert pressure into rotating motion. They are commonly used at power and manufacturing plants to generate electricity and to power pumps and compressors. RICEs are also used in emergencies to produce electricity and pump water for flood and fire control. Recently, EPA finalized new air quality regulations that place requirements on owners and operators of a wide variety of stationary RICEs (ADEQ No Date). While USACE project locations utilize RICEs in the forms of operational or emergency generators, they are operated under the limit allowed; therefore, no air emissions reporting is required.

#### *3.10.2.6 Oregon Air Quality Permits*

This section discusses Oregon's air quality permits that strictly relate to the Proposed Action and alternatives. The primary sources of air emissions are diesel generator usage and diesel trucks during fish trucking operations. There are no new or preexisting major stationary sources included in the Proposed Action or alternatives. Major sources are defined by the CAA as facilities that emit or have the potential to emit 10 tons of any one toxic air pollutant or 25 tons of more than one toxic air pollutant per year (EPA 2021d). In addition, all USACE project locations are located within attainment areas, as discussed in Section 3.10.2.2. Therefore, Prevention of Significant Deterioration (PSD) permits, nonattainment New Source Review (NSR) permits, minor NSR permits, and Title V permits are not applicable and may be dismissed from further discussion. Only permits that would be applicable to USACE projects and emission sources will be discussed below.

#### *3.10.2.7 Air Contaminant Discharge Permits*

ODEQ and LRAPA set permit rules and limits based on the size and type of the emission source and the type of pollutant emitted. Facilities that emit air pollution above certain levels are required to have air quality permits that specify the pollutant limits they must meet and what records they must keep and submit to ODEQ to show they are in compliance (ODEQ No Date-d). Air Contaminant Discharge Permits (ACDP) are primarily used to regulate minor sources of air contaminant emissions, but are also required for any new major source or major modification at a major source. Types of air contaminant discharge permits can vary based on the source category, size of the facility, and types of emissions discharged (ODEQ No Date-a).

General ACDPs authorize the operation of electrical power generators, and are issued for a period of up to ten years. Device and Equipment Form Series 200, AQ 213 'Electric Power Generators' provides the application form that must include information for each generator used, including the size of the generator, type of fuel used, and projected maximum number of hours to be operated in one year.

Construction ACDPs include requirements for the construction or modification of stationary sources or air pollution control equipment at sources that are required to obtain a Standard ACDP or Oregon Title V Operating Permit. None of the construction activities under the Proposed Action or alternatives would result in a stationary source that would require either of these permits. Therefore, a construction ACDP would not be required under the Proposed Action and alternatives.

### 3.10.3 Environmental Effects

This section discusses the potential effects of the Proposed Action and alternatives on air quality. The discussion includes the methodology, the measures within the action alternatives that were analyzed, a summary of the effects, and a detailed analysis for each alternative.

#### *3.10.3.1 Methodology*

The two primary existing sources of air emissions in the WVS are fish trucking operations and generator usage. These sources would likely contribute air pollutants that have been identified by federal and state standards (Sections 3.10.2.1. and 3.10.2.2., respectively), with regulatory thresholds that cannot be exceeded in order to maintain attainment status. To analyze these sources, USACE project data were assessed to qualitatively determine how the Proposed Action and alternatives would affect air quality. The current total mileage of all fish trucking operations and the total number of WVS emergency diesel generators were accounted for in the Affected Environment (Section 3.10.1.1). Both of these parameters would likely change based on the proposed measures in each alternative. In general, more fish trucking mileage and generator usage would directly correlate with higher emissions of carbon dioxide and other criteria pollutants, thereby potentially affecting the air quality in the WVS. Therefore, the changes in total fish trucking mileage and total generators per alternative were qualitatively assessed below to determine how each alternative would potentially affect air quality, and if any alternative would potentially exceed any federal or state standard.

Table 3.10-4 describes the evaluation criteria for magnitude, duration, and extent, and provides a definition for the scale of each effect factor. Note that the definitions for short term, medium term, and long term are the same for all resources.

**Table 3.10-4. Evaluation Criteria for Potential Effects to Air Quality**

| Term | Definition |
| --- | --- |
| **Magnitude** | |
| Negligible | Changes would be nondetectable and indistinguishable from ambient air quality conditions. |
| Minor | Change would not exceed 50% of a federal or state standard. |
| Moderate | Change would exceed 50% of a federal or state standard. |
| Major or Significant | Change would exceed a federal or state standard. |
| **Duration** | |
| Short term | Effects lasts for the duration of a small construction project, and is continuous for less than 2 years. |
| Medium term | Effects lasts for the duration of large construction projects, and is continuous for a period of 2-5 years. |
| Long term | Effects are permanent or last continuously beyond operation changes or the completion of all construction projects; the effects recur at regular intervals (i.e., trap-and-haul trucking operations that occur weekly or monthly); or the alteration occurs intermittently. |
| **Extent** | |
| Small | Effects would be confined to the project location. |
| Medium | Effects would be confined to a single county. |
| Large | Effects would extend to multiple counties or throughout the entire WVS, state, or beyond. |

Secondary sources of air emissions include construction activities and fugitive dust. The use of construction vehicles and equipment, such as bulldozers, cranes, and other heavy equipment, results in tailpipe emissions to the air through the internal combustion of diesel engines. To analyze construction activities, a qualitative approach was implemented that considers the amount of equipment used, the duration of equipment used, and the area of construction activities. Windblown fugitive dust from unpaved roads and heavy construction equipment or as a result of reservoir drawdowns could expose sediment and result in air emissions. To analyze fugitive dust, a qualitative approach was implemented that considered average wind speeds at locations within the WRB in conjunction with the duration of equipment used or reservoir drawdowns and the area of construction activities or reservoir drawdowns to assess potential fugitive dust emissions.

#### *3.10.3.2 Measures Analyzed for Air Quality*

Measures under the action alternative that could have an effect on air quality include construction of water temperature control (WTC) towers (#105), construction of adult fish facilities (AFF) (#722), construction of structural downstream fish passages (#392), restoring upstream and downstream passage at drop structures (#639), providing Pacific lamprey passage and infrastructure (#52), deeper fall reservoir drawdowns for fish passage (#40), and spring reservoir drawdowns for downstream fish passage (#720).

The following measures would have no effect on air quality, and are therefore not discussed further.

- Gravel augmentation below dams (#384);
- Foster fish ladder temperature improvement (#479);
- Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166);
- Use spillway for surface spill in summer (#721);
- Structural improvements to reduce total dissolved gas (#174);
- Augment instream flows by using the inactive pool (#718);
- Augment instream flows by using the power pool (#304);
- Reduce minimum flows to Congressionally authorized minimum flow requirements (#723);
- Integrated temperature and habitat flow regime (#30a);
- Refined integrated temperature and habitat flow regime (#30b); and
- Pass water over spillway in spring for fish passage (#714).

Operation, maintenance, repair, replacement, and rehabilitation can range from regular maintenance activities to major maintenance and rehabilitation activities, such as the repair, replacement, or rehabilitation of an entire facility. Major maintenance projects that take power lines off-line or shut down generators would likely reduce air emissions and could have beneficial effects to air quality. Alternatively, construction vehicles and equipment used during major rehabilitation or restoration projects would likely generate additional air emissions and adversely affect air quality. As such, major maintenance and rehabilitation activities would likely have **negligible**, **medium-term** effects to air quality; however, more information is needed to conduct a full analysis. These actions should undergo further analysis under the tiered NEPA process.

A summary of the effects to air quality discussed in the following section is provided in Table 3.10-5. Note that where a range of potential effects would occur, the most severe magnitude of adverse effects and the lesser magnitude of beneficial effects for each alternative was listed in this table. For example, if there is a range of minor to moderate adverse effects, moderate adverse effects are included in the table. If beneficial effects would range from minor to moderate, the table includes minor beneficial effects. Said otherwise, the most conservative conclusions of potential effects are presented in the table below in order to avoid overstating potential beneficial effects and understating adverse effects. Discussion of all adverse and beneficial effects are included in the discussion below.

**All comparisons of effects for each action alternative are in comparison to the NAA unless stated otherwise.**

**Table 3.10-5. Summary of Effects to Air Quality Under Each Alternative**

| Effect Factor | Alternative | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **NAA** | **1** | **2A** | **2B** | **3A** | **3B** | **4** | **5** |
| | **Short-Term** | | | | | | | |
| Magnitude | negligible adverse | minor adverse | minor adverse | minor adverse | minor adverse | minor adverse | minor adverse | minor adverse |
| Extent | Small (FCR) | Small (FRN) | Small (GRP) | Small (GRP, CGR) | Small (DET, GRP, LOP, HCR, BLU, CGR) | Small (DET, GRP, LOP, HCR, BLU, CGR) | Small (FRN) | Small (GRP, CGR) |
| | **Medium-Term** | | | | | | | |
| Magnitude | Negligible adverse | minor adverse | minor adverse | minor adverse | minor adverse | minor adverse | minor adverse | minor adverse |
| Extent | Large (basin-wide) | Small (DET, GRP, LOP, FOS, CGR) | Small (DET, GRP, LOP, FOS, CGR) | Small (DET, GRP, LOP, FOS, CGR) | Small (BLU, GRP, HCR, CGR) | Small (BLU, GRP, HCR, CGR) | Small (DET, GRP, LOP, HCR, FOS, CGR) | Small (DET, LOP, FOS, CGR) |
| | **Long-Term (Permanent, Intermittent, and/or Recurring)** | | | | | | | |
| Magnitude | Negligible adverse | minor adverse; minor beneficial | minor adverse | minor adverse | minor adverse | minor adverse | minor adverse; minor beneficial | minor adverse |
| Extent | Small (FCR)<br><br>Large (basin-wide) | Small (FRN)<br><br>Large (DET, GRP, LOP, FOS, CGR) | Small (GRP)<br><br>Large (DET, GRP, LOP, FOS, CGR) | Small (GRP, CGR)<br><br>Large (DET, GRP, LOP, FOS, CGR) | Small (DET, GRP, LOP, HCR, BLU, CGR)<br><br>Large (BLU, GRP, HCR, CGR) | Small (DET, GRP, LOP, HCR, BLU, CGR)<br><br>Large (BLU, GRP, HCR, CGR) | Small (FRN)<br><br>Large (DET, GRP, LOP, HCR, FOS, CGR) | Small (GRP, CGR)<br><br>Large (DET, LOP, FOS, CGR) |

| Effect Factor | Alternative | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **NAA** | **1** | **2A** | **2B** | **3A** | **3B** | **4** | **5** |
| | **Short-Term** | | | | | | | |
| Duration Type | Intermittent and/or Recurring | Permanent and/or Recurring | Permanent and/or Recurring | Permanent and/or Recurring | Permanent and/or Recurring | Permanent and/or Recurring | Permanent and/or Recurring | Permanent and/or Recurring |

In the following subsections, the effects are discussed for the measures analyzed in the alternatives, the No Action Alternative, and for each of the action alternatives.

### *3.10.3.3 Discussion of Effects by Measure(s)*

This section applies the methodology described above to each measure analyzed for air quality to determine the potential effect. Where possible, discussion of the magnitude, duration, and extent of effects is grouped by measures that would have similar effects. The effects by measure or measures will then be referenced in the action alternatives analysis that follows.

This Draft PEIS discusses general, qualitative effects from construction at the programmatic level, and all structural measures that include construction phases would require tiered NEPA reviews. Structural measures pertaining to air quality include construction of WTC towers, construction of AFFs, construction of structural downstream fish passage, restoring upstream and downstream passage at drop structures, deeper fall reservoir drawdowns (only at Cougar for the drawdown operation to the DT), and spring reservoir drawdowns (only at Cougar for the drawdown operation to the DT). Because air quality effects from each individual construction project analyzed in subsequent tiered NEPA documents are expected to be lower than those from the sum of all projects analyzed in this PEIS, the analysis in subsequent tiered NEPA documents is not expected to be more detailed or quantitative. It is expected that the air quality analysis in the tiered EAs or EISs would be able to incorporate by reference the applicable parts of the analysis from this PEIS. However, if site-specific project details for construction measures determined during the implementation phase indicate potentially higher air emissions than those discussed in this PEIS, a quantitative analysis may be considered in that tiered EA or EIS.

#### *3.10.3.3.1 Construct water temperature control (WTC) towers (#105), Construct structural downstream fish passages (#392), Construct adult fish facilities (AFFs) (#722), and Provide Pacific lamprey passage and infrastructure (#52)*

The magnitude of effects from the construction of WTC towers (#105), structural downstream fish passages (#392), AFFs (#722), and Pacific Lamprey passage and infrastructure (#52) would be negligible to minor in the medium term and small in extent, and negligible to minor in the long term (recurring) and large in extent at all dams. These potential effects are determined below and referred back to under all alternatives.

**Construction Activities and Fugitive Dust**

Construction vehicles and equipment, such as bulldozers, cranes, and other heavy equipment, would be required to complete the proposed measures. The effects to air quality would include the combustion of diesel fuel to power construction vehicles and machinery. During combustion, diesel engines emit large amounts of nitrogen oxides, particular matter (in particular $PM_{2.5}$) carbon, and other toxic air pollutants. Given the nature and scale of these proposed construction projects, the effects to local and regional air quality would be expected to be minimal and the magnitude of adverse effects would be negligible to minor because air emissions would not exceed 50% of a federal or state standard. There would be a medium-term effect because the construction activities would take two to five years to complete. The extent of effects would be small because construction activities typically result in localized air pollution emissions, and would be confined to the project location.

Fugitive dust emissions are caused by two basic factors: the pulverization and abrasion of surface materials by the application of a mechanical force (wheels, blades, etc.), and/or the entrainment of dust (sediment) particles by turbulent air currents, such as wind erosion of an exposed surface by wind speeds over 12 miles per hour (mph) (EPA 1995). Average wind speeds for 2021 in Eugene and Salem were 6.9 and 6.5 mph, respectively (NOAA 2022a, 2022b). The magnitude of adverse effects would be negligible because average wind speeds would not be high enough to entrain dust particles into surface winds. Furthermore, Oregon Administrative Rules (OAR) 340-208-0210 provides the management requirements for fugitive emissions, including disciplinary action that would be taken by Oregon Department of Environmental Quality (ODEQ) (see Section 3.10.1.3). There would be a medium-term effect because construction activities would take two to five years to complete. The extent of effects would be small because construction activities typically result in localized air pollution emissions, and would be confined to the project location.

**Operational Activities**

Each of these measures would increase the number of fish collected at each project site and increase the need for transportation to release sites, thereby increasing fish trucking mileage and associated air emissions. New facilities and structures at each project site would also require emergency diesel generators to supply power to these measures, thereby increasing associated air emissions.

The total fish trucking mileage and the number of generators would vary by alternative, as each alternative contains a different combination of measures and project sites that would affect these totals. While these parameters are analyzed per alternative, it is not likely that total fish trucking mileage and emergency diesel generators would exceed 50% of a federal or state standard in any alternative. Under routine operations, the WVS accounts for 22 emergency diesel generators and an estimated 92,000 vehicle miles traveled from fish trucking operations as stated in the Affected Environment (Section 3.10.1.1). By comparison, the Rose Quarter Freeway, which is the section of I-5 near Portland in Willamette Valley, carries about 120,000 vehicles per day and accounts for about 35 million vehicles miles of travel per year (Cortright 2019). Under each alternative, fish trucking mileage would only increase by about 576 to 1,216 miles, which is an increase of about one percent; similarly, each alternative would only add between seven to ten new generators. Therefore, the magnitude of adverse effects would be negligible to minor because the additional air emissions from truck mileage and generators would not exceed 50% of a federal or state standard and would likely be undetectable compared to the entire geographical region of the WVS. There would be a long-term, recurring effect because while the structures would be permanent, the fish trucking operations would be recurring. The extent of effects would be large because the release sites for trucked fish would potentially be located in various counties across the WRB.

#### *3.10.3.3.2 Restoring upstream and downstream passage at drop structures (#639)*

The magnitude of effects from restoring upstream and downstream passage at drop structures (#639) would be negligible to minor in the short term and small in extent, and minor in the long term (permanent) and small in extent at Fern Ridge Dam. These potential effects are determined below and referred back to under Alternatives 1 and 4.

Infrastructure would be improved downstream of the Fern Ridge Dam at Monroe, Stroda, and Cox Butte. Infrastructure improvements include fish ladders, notching or direct modifications to drop structures, bypass channels, or dam removal and replacement with pool and riffle systems. Construction vehicles and equipment, such as bulldozers, cranes, and other heavy equipment, would be required to complete the proposed improvements. Given the nature and scale of these proposed construction projects, the effects to local and regional air quality would be expected to be minimal. Therefore, the magnitude of adverse effects would be negligible to minor because air emissions would not exceed 50% of a federal or state standard. There would be a short-term effect because the construction activities would take less than two years to complete. The extent of effects would be small because construction activities typically result in localized air pollution emissions, and would be confined to the project location.

Fugitive dust emissions would be negligible because average wind speeds for 2021 in Eugene and Salem were 6.9 and 6.5 mph, respectively (NOAA, 2022a; NOAA, 2022-b), and would not be high enough to entrain dust particles into surface winds. There would be a short-term effect because construction activities would take less than two years to complete. The extent of effects would be small because construction activities typically result in localized air pollution emissions, and would be confined to the project location.

Once construction is complete, the infrastructure would provide passage for fish to the mainstem Long Tom River and tributaries between the confluence with the Willamette River and Fern Ridge Dam. The magnitude of beneficial effects would be minor because fish passage measures would allow fish to pass through the Fern Ridge Dam without being trapped and hauled, reducing the amount of total fish trucking mileage. There would also be no additional generators added to this measure. These effects would occur in the long-term because the structures would be permanent and fish would no longer require transportation. The extent of effects would be small because the fish passage infrastructure at the drop structures would be localized and confined to that project location.

#### *3.10.3.3.3 Deeper fall reservoir drawdowns for fish passage (#40) and spring reservoir drawdowns for downstream fish passage (#720)*

The magnitude of effects from deeper fall reservoir drawdowns (#40) and spring reservoir drawdowns (#720) would be negligible in the short and long term (recurring) and small in extent at all reservoirs. These potential effects are determined below and referred back to under Alternatives 2, 3A, 3B, and 5.

As reservoir elevations are drawn down for extended periods of time, methane could be released from the sediments and potentially represent a substantial contribute of methane to the atmosphere. However, the magnitude of these effects would likely be negligible because methane released specifically during drawdowns have been measured to only contribute a small fraction of the total amount of methane emitted at reservoirs throughout the year (Beaulieu et al. 2018). Sediments from the shoreline to the benthic zone can also become exposed and dried out as reservoir elevations fall, and would likely be susceptible to atmospheric weather conditions. Fugitive dust emissions could be caused by the entrainment of dust (sediment) particles by turbulent air currents, such as wind erosion of an exposed surface by wind speeds over 12 mph (EPA 1995). Average wind speeds for 2021 in Eugene and Salem were 6.9 and 6.5 mph, respectively (NOAA 2022a, 2022b). The magnitude of adverse effects would be negligible because average wind speeds would not be high enough to entrain dust particles into surface winds. Reservoir drawdowns would only be maintained for 3-week periods in the spring and fall; this short time span would make it highly unlikely for sediments to be completely dried out, and for wind speeds to reach above average speeds. Furthermore, OAR 340-208-0210 provides the management requirements for fugitive emissions, including taking precautions to prevent particular matter from being airborne, such as using water, chemicals or enclosures and covers for dust control, and disciplinary action that would be taken by ODEQ (see Section 3.10.1.3). There would be **short-term** and long-term, recurring effects because while reservoir elevations would only be held for three weeks, it would occur annually. The extent of effects would be small because reservoir drawdowns would be confined to the project location.

##### *3.10.3.3.4 Near-Term Operations*

The magnitude of effects from near-term operations would be negligible in the short term or medium term at Green Peter Dam. These potential effects are determined below and referenced under Alternatives 2A, 2B, 3A, 3B, 4, and 5.

Near-term operations that would potentially affect air quality include the outplanting plan for the reintroduction of adult Chinook salmon above Green Peter Dam. While the outplanting plan could increase the total fish trucking mileage occurring at Green Peter Dam, it is unlikely to cause a substantial change to the overall total fish trucking mileage occurring within the WVS. Therefore, potential adverse effects would be negligible in magnitude. It should be noted that duration of near-term operations ultimately would depend on when the operations each location in the action alternatives can be implemented; therefore, duration of effects would be short term and/or medium term, depending on the implementation process of measures in the action alternatives. Effects would be medium and/or large in extent because the release sites for trucked fish could potentially be located in various areas within the country or across the WRB.

Near-term operations would also include deep drawdown and RO prioritization at Lookout Point, Green Peter, and Cougar; delayed refill at Fall Creek, Foster, and Cougar; and extended deep drawdown and RO prioritization at Fall Creek. Drawdowns would expose previously submerged sediments and dry them out, leaving them susceptible to atmospheric conditions that could entrail the sediments and create fugitive dust emissions. Similar to 3.10.3.3.3, the magnitude of adverse effects would be negligible because average wind speeds would not be high enough to entrain dust particles into surface winds. While these drawdowns would last longer than three weeks and could potentially dry out sediments even further, low wind speeds would make fugitive dust very unlikely. Duration of effects would be short term and/or medium term, depending on the implementation process of measures in the action alternatives. The extend of effects would be small because reservoir drawdowns would be confined to the project location.

#### *3.10.3.4 No Action Alternative*

Under the NAA, the adaptive hatchery program (#719) would occur at Detroit, Big Cliff, Green Peter, Foster, Blue River, Cougar, Dexter, Lookout Point, Fall Creek, and Hills Creek Dams. In addition, the continued operation of AFFs would occur at Dexter Dam, Cougar, Foster, and Fall Creek Dams, and Minto Fish Collection Facility, and the maintenance of existing and new fish release sites (#726) would occur at Detroit, Green Peter, Foster, Cougar, Lookout Point, Fall Creek, Hills Creek, and Big Cliff Dams. The magnitude of adverse effects from these activities would be negligible in the long term because these activities would not change the total truck mileage or the number of generators from current levels, and therefore, would not cause a change in air emissions different from what was already occurring. The extent of effects would be large because the hatcheries, AFFs, and release sites for outplanted fish would potentially be located in various counties across the WRB.

Under the NAA, Fall Creek reservoir would continue to be drawn down annually to its lowest outlet (elevation 690) for a few weeks in November, potentially lasting into December. As discussed above in Section 3.10.3.3.3 (Reservoir Drawdowns), the potential adverse **short-** and long-term, recurring effects from these drawdowns would be negligible in magnitude and small in extent.

##### *3.10.3.4.1 Climate Change*

Climate change would potentially affect air quality within the WVS. More intense and frequent wildfires would release pollutants such as particulate matter, carbon monoxide, and carbon dioxide into the air and affect air quality in the surrounding area. Ambient air temperature changes, such as the one-to-two-degree Fahrenheit warming experienced in the Pacific Northwest (See Appendix F1), could increase ground-level ozone and make wildfires more common due to drier conditions from higher evapotranspiration rates. Likewise, these air pollutants could also contribute to climate change; carbon dioxide released during wildfires would contribute to greenhouse gases increasing in the atmosphere, while particulate matter and ozone could create smog that blocks sunlight and could be harmful to human health. Therefore, climate change would amplify the effects to air quality already occurring under the

NAA to minor adverse effects. Effects would be long-term in duration due to the ongoing nature of climate change, and large in extent depending on the size of wildfires and the distance pollutants would travel, along with the widespread effects air pollutants such as carbon dioxide, particulate matter, and ozone have on greenhouse gases in the atmosphere.

#### *3.10.3.5 Alternative 1. Improve Fish Passage Through Storage-Focused Measures*

Under Alternative 1, adverse effects on air quality from the construction of WTC towers, structural downstream fish passages, AFFs, and Pacific Lamprey passage and infrastructure would be negligible to minor in the medium term and small in extent, and negligible to minor in the long term (recurring) and large in extent. Potential adverse effects from restoring upstream and downstream passage at drop structures would be negligible to minor in magnitude in the short term and small in extent. Potential beneficial effects from restoring upstream and downstream passage at drop structures would be minor in magnitude in the long term (permanent) and small in extent. Alternative 1 would have the same general effect as all other alternatives.

##### *3.10.3.5.1 Construction of WTC Towers, Structural Downstream Fish Passages, AFFs, and Pacific Lamprey Passage and Infrastructure*

Under Alternative 1, the construction of WTC towers would occur at Detroit Dam, Green Peter Dam, and Lookout Point Dam. Downstream fish passage structures would occur at Detroit Dam, Green Peter Dam, Lookout Point Dam, and Foster Dam. The construction of AFFs would occur at Green Peter Dam. Pacific Lamprey passage and infrastructure would occur at Fern Ridge Dam and Green Peter Dam. As discussed above in Section 3.10.3.3.1 (Construction of WTC Towers, Structural Downstream Fish Passages, AFFs, and Pacific Lamprey Passage and Infrastructure), the potential adverse medium- and long-term, recurring effects from these structures would be negligible to minor in magnitude and small and large in extent. New structures would require nine new emergency diesel generators, and measures would add a total of 576 miles to fish trucking operations, while is a mileage increase of less than one percent. These additional air emissions would not exceed 50% of a federal or state standard and would likely be undetectable compared to the entire geographical region of the WVS.

##### *3.10.3.5.2 Restoring Upstream and Downstream Passage at Drop Structures*

Under Alternative 1, restoring upstream and downstream passage at drop structures would occur at Fern Ridge. As discussed above in Section 3.10.3.3.2 (Restoring Upstream and Downstream Passage at Drop Structures), the potential adverse short-term effects would be negligible to minor in magnitude and small in extent. Potential beneficial long-term, permanent effects would be minor in magnitude and small in extent.

##### *3.10.3.5.3 Climate Change*

As discussed in Section 3.10.3.4.1, climate change would potentially affect air quality within the WVS. More intense and frequent wildfires would release more air pollutants, such as carbon dioxide, particulate matter, and ozone, while ambient air temperatures changes could increase ground-level ozone and make wildfires (and their associated emissions) more common. These effects would exacerbate the effects to air quality already occurring under Alternative 1. Therefore, climate change would amplify the effects to air quality already occurring under Alternative 1 to minor adverse effects. Effects would be long-term in duration due to the ongoing nature of climate change, and large in extent depending on the size of wildfires and the distance pollutants would travel, along with the widespread effects air pollutants such as carbon dioxide, particulate matter, and ozone have on greenhouse gases in the atmosphere.

#### ***3.10.3.6 Alternative 2A. Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam)***

Under Alternative 2A, adverse effects on air quality from the construction of WTC towers, downstream passage structures, AFFs, and Pacific Lamprey passage and infrastructure would be negligible to minor in magnitude in the medium term and long term (recurring) and small and large in extent. Reservoir drawdowns would have negligible, **short-term** and long-term, recurring effects and would be small in extent. Alternative 2A would have the same general effect as all other alternatives.

##### *3.10.3.6.1 Construction of WTC Towers, Structural Downstream Fish Passages, AFFs, and Pacific Lamprey Passage and Infrastructure*

Under Alternative 2A, the construction of WTC towers would occur at Detroit Dam. Construction of downstream fish passage structures would occur at Detroit Dam, Lookout Point Dam, Cougar Dam, and Foster Dam. The construction of AFFs would occur at Green Peter Dam. Pacific Lamprey passage and infrastructure would occur at Green Peter Dam. As discussed above in Section 3.10.3.3.1 (Construction of WTC Towers, Downstream Fish Passages, AFFs, and Pacific Lamprey Passage and Infrastructure), the potential adverse medium- and long-term, recurring effects from these structures would be negligible to minor in magnitude and small and large in extent. New structures would require eight new emergency diesel generators, and measures would add a total of 736 miles to fish trucking operations, which is a mileage increase of less than one percent. These additional air emissions would not exceed 50% of a federal or state standard and would likely be undetectable compared to the entire geographical region of the WVS.

##### *3.10.3.6.2 Reservoir Drawdowns*

Under Alternative 2A, deeper fall reservoir drawdowns to 25 feet over the ROs would occur at Green Peter Dam. As discussed above in Section 3.10.3.3.3 (Reservoir Drawdowns), the potential adverse **short-term** and long-term, recurring effects from these drawdowns would be negligible in magnitude and small in extent.

#### *3.10.3.6.3 Near-Term Operations*

As discussed in Section 3.10.3.3.4, potential adverse short- or medium-term effects from near-term operations from the outplanting plan for the reintroduction of adult Chinook salmon above Green Peter Dam would be negligible in magnitude. Effects would be medium and/or large in extent because the release sites for trucked fish could potentially be located in various areas within the country or across the WRB. In addition, short- or medium-term effects from deep drawdown and RO prioritization at Lookout Point, Green Peter, and Cougar; delayed refill at Fall Creek, Foster, and Cougar; and extended deep drawdown and RO prioritization at Fall Creek would be negligible in magnitude at all dams. Effects would be small in extent because reservoir drawdowns would be confined to the project location.

#### *3.10.3.6.4 Climate Change*

As discussed in Section 3.10.3.4.1, climate change would potentially affect air quality within the WVS. More intense and frequent wildfires would release more air pollutants, such as carbon dioxide, particulate matter, and ozone, while ambient air temperatures changes could increase ground-level ozone and make wildfires (and their associated emissions) more common. These effects would exacerbate the effects to air quality already occurring under Alternative 2A. Therefore, climate change would amplify the effects to air quality already occurring under Alternative 2A to minor adverse effects. Effects would be long-term in duration due to the ongoing nature of climate change, and large in extent depending on the size of wildfires and the distance pollutants would travel, along with the widespread effects air pollutants such as carbon dioxide, particulate matter, and ozone have on greenhouse gases in the atmosphere.

### ***3.10.3.7 Alternative 2B. Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)***

Under Alternative 2B, the effects to air quality would be the same as those described under Alternative 2A. Potential adverse effects from the construction of WTC towers, structural downstream fish passages, AFFs, and Pacific Lamprey passage and infrastructure would be negligible to minor in the medium term and small in extent, and negligible to minor in the long term (recurring) and large in extent. Reservoir drawdowns would have negligible, **short-term** and long-term, recurring effects and would be small in extent. Under this alternative, a downstream passage structure would not be constructed at Cougar Dam; and deep fall and spring reservoir drawdowns down to 25 feet over the top of the diversion tunnel would occur at Cougar Dam. Similar to Alternative 2A, total fish trucking mileage would increase by 736 miles and emergency diesel generators would increase by seven new generators under Alternative 2B. Alternative 2B would have the same general effect as all other alternatives.

#### *3.10.3.7.1 Near-Term Operations*

As discussed in Section 3.10.3.3.4, potential adverse short- or medium-term effects from near-term operations from the outplanting plan for the reintroduction of adult Chinook salmon above Green Peter Dam would be negligible in magnitude. Effects would be medium and/or large in extent because the release sites for trucked fish could potentially be located in various areas within the country or across the WRB. In addition, short- or medium-term effects from deep drawdown and RO prioritization at Lookout Point, Green Peter, and Cougar; delayed refill at Fall Creek, Foster, and Cougar; and extended deep drawdown and RO prioritization at Fall Creek would be negligible in magnitude at all dams. Effects would be small in extent because reservoir drawdowns would be confined to the project location.

#### *3.10.3.7.2 Climate Change*

As discussed in Section 3.10.3.4.1, climate change would potentially affect air quality within the WVS. More intense and frequent wildfires would release more air pollutants, such as carbon dioxide, particulate matter, and ozone, while ambient air temperatures changes could increase ground-level ozone and make wildfires (and their associated emissions) more common. These effects would exacerbate the effects to air quality already occurring under Alternative 2B. Therefore, climate change would amplify the effects to air quality already occurring under Alternative 2B to minor adverse effects. Effects would be long-term in duration due to the ongoing nature of climate change, and large in extent depending on the size of wildfires and the distance pollutants would travel, along with the widespread effects air pollutants such as carbon dioxide, particulate matter, and ozone have on greenhouse gases in the atmosphere.

### ***3.10.3.8 Alternative 3A. Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)***

Under Alternative 3A, adverse effects on air quality from the construction of AFFs and Pacific Lamprey passage and infrastructure would be negligible to minor in the medium term and small in extent, and negligible to minor in the long term (recurring) and large in extent. Reservoir drawdowns would have negligible, **short-term** and long-term, recurring effects and would be small in extent. Alternative 3A would have the same general effect as all other alternatives.

#### *3.10.3.8.1 Construction of AFFs and Pacific Lamprey Passage and Infrastructure*

Under Alternative 3A, the construction of AFFs would occur at Blue River Dam, Green Peter Dam, and Hills Creek Dam. Pacific Lamprey passage and infrastructure would occur at Blue River Dam, Green Peter Dam, and Hills Creek Dam. As discussed above in Section 3.10.3.3.1 (Construction of WTC Towers, Downstream Fish Passages, AFFs, and Pacific Lamprey Passage and Infrastructure), the potential adverse medium- and long-term, recurring effects from these structures would be negligible to minor in magnitude and small and large in extent. New structures would require seven new emergency diesel generators, and measures would add a total of 1,216 miles to fish trucking operations, which is a mileage increase of almost 1.5

percent. These additional air emissions would not exceed 50% of a federal or state standard and would likely be undetectable compared to the entire geographical region of the WVS.

##### *3.10.3.8.2 Reservoir Drawdowns*

Under Alternative 3A, deeper fall reservoir drawdowns to 10 feet over the ROs would occur at Lookout Point Dam, Hills Creek Dam, Cougar Dam, Blue River Dam, Green Peter Dam, and Detroit Dam. Spring reservoir drawdowns to 10 feet over the ROs would occur at Lookout Point Dam, Cougar Dam, and Detroit Dam. As discussed above in Section 3.10.3.3.3 (Reservoir Drawdowns), the potential adverse **short-term** and long-term, recurring effects from these drawdowns would be negligible in magnitude and small in extent.

##### *3.10.3.8.3 Near-Term Operations*

As discussed in Section 3.10.3.3.4, potential adverse short- or medium-term effects from near-term operations from the outplanting plan for the reintroduction of adult Chinook salmon above Green Peter Dam would be negligible in magnitude. Effects would be medium and/or large in extent because the release sites for trucked fish could potentially be located in various areas within the country or across the WRB. In addition, short- or medium-term effects from deep drawdown and RO prioritization at Lookout Point, Green Peter, and Cougar; delayed refill at Fall Creek, Foster, and Cougar; and extended deep drawdown and RO prioritization at Fall Creek would be negligible in magnitude at all dams. Effects would be small in extent because reservoir drawdowns would be confined to the project location.

##### *3.10.3.8.4 Climate Change*

As discussed in Section 3.10.3.4.1, climate change would potentially affect air quality within the WVS. More intense and frequent wildfires would release more air pollutants, such as carbon dioxide, particulate matter, and ozone, while ambient air temperatures changes could increase ground-level ozone and make wildfires (and their associated emissions) more common. These effects would exacerbate the effects to air quality already occurring under Alternative 3A. Therefore, climate change would amplify the effects to air quality already occurring under Alternative 3A to minor adverse effects. Effects would be long-term in duration due to the ongoing nature of climate change, and large in extent depending on the size of wildfires and the distance pollutants would travel, along with the widespread effects air pollutants such as carbon dioxide, particulate matter, and ozone have on greenhouse gases in the atmosphere.

#### ***3.10.3.9 Alternative 3B. Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)***

Under Alternative 3B, the effects to air quality would be the same as those described under Alternative 3A. Potential adverse effects from the construction of AFFs and Pacific Lamprey passage and infrastructure would be negligible to minor in the medium term and small in extent, and negligible to minor in the long term (recurring) and large in extent. Reservoir drawdowns would have negligible, **short-term** and long-term, recurring effects and would be small in extent. Under this alternative, spring reservoir drawdowns would occur at Green Peter and Hills Creek instead of at Detroit and Lookout Point under Alternative 3A. In addition, Cougar would be drafted down to 25 ft over the top of the diversion tunnel, similar to Alternative 2B. Similar to Alternative 3A, total fish trucking mile would increase by 1,216 miles and emergency diesel generators would increase by seven new generators under Alternative 3B. Alternative 3B would have the same general effect as all other alternatives.

##### *3.10.3.9.1 Near-Term Operations*

As discussed in Section 3.10.3.3.4, potential adverse short- or medium-term effects from near-term operations from the outplanting plan for the reintroduction of adult Chinook salmon above Green Peter Dam would be negligible in magnitude. Effects would be medium and/or large in extent because the release sites for trucked fish could potentially be located in various areas within the country or across the WRB. In addition, short- or medium-term effects from deep drawdown and RO prioritization at Lookout Point, Green Peter, and Cougar; delayed refill at Fall Creek, Foster, and Cougar; and extended deep drawdown and RO prioritization at Fall Creek would be negligible in magnitude at all dams. Effects would be small in extent because reservoir drawdowns would be confined to the project location.

##### *3.10.3.9.2 Climate Change*

As discussed in Section 3.10.3.4.1, climate change would potentially affect air quality within the WVS. More intense and frequent wildfires would release more air pollutants, such as carbon dioxide, particulate matter, and ozone, while ambient air temperatures changes could increase ground-level ozone and make wildfires (and their associated emissions) more common. These effects would exacerbate the effects to air quality already occurring under Alternative 3B. Therefore, climate change would amplify the effects to air quality already occurring under Alternative 3B to minor adverse effects. Effects would be long-term in duration due to the ongoing nature of climate change, and large in extent depending on the size of wildfires and the distance pollutants would travel, along with the widespread effects air pollutants such as carbon dioxide, particulate matter, and ozone have on greenhouse gases in the atmosphere.

#### ***3.10.3.10 Alternative 4. Improve Fish Passage with Structures-Based Approach***

Under Alternative 4, the effects to air quality would be the same as those described under Alternative 1. Potential adverse effects from the construction of WTC towers, structural downstream fish passages, AFFs, and Pacific Lamprey passage and infrastructure would be negligible to minor in the medium term and small in extent, and negligible to minor in the long term (recurring) and large in extent. Potential adverse effects from restoring upstream and downstream passage at drop structures would be negligible to minor in magnitude in the short term and small in extent. Potential beneficial effects from restoring upstream and downstream passage at drop structures would be minor in magnitude in the long term (permanent) and small in extent. Under this alternative, a WTC tower and new AFF would be constructed at Hills Creek instead of Green Peter under Alternative 1; and structural downstream fish passages would be constructed at Hills Creek and Cougar instead of Green Peter, in addition to those listed under Alternative 1. Pacific Lamprey passage and infrastructure would also be constructed at Hills Creek instead of Green Peter, in addition to those already listed under Alternative 1. Under Alternative 4, ten new emergency diesel generators would be added, and 800 miles would be added to total fish trucking. Alternative 4 would have the same general effect as all other alternatives.

##### *3.10.3.10.1 Near-Term Operations*

As discussed in Section 3.10.3.3.4, potential adverse short- or medium-term effects from near-term operations from the outplanting plan for the reintroduction of adult Chinook salmon above Green Peter Dam would be negligible in magnitude. Effects would be medium and/or large in extent because the release sites for trucked fish could potentially be located in various areas within the country or across the WRB. In addition, short- or medium-term effects from deep drawdown and RO prioritization at Lookout Point, Green Peter, and Cougar; delayed refill at Fall Creek, Foster, and Cougar; and extended deep drawdown and RO prioritization at Fall Creek would be negligible in magnitude at all dams. Effects would be small in extent because reservoir drawdowns would be confined to the project location.

##### *3.10.3.10.2 Climate Change*

As discussed in Section 3.10.3.4.1, climate change would potentially affect air quality within the WVS. More intense and frequent wildfires would release more air pollutants, such as carbon dioxide, particulate matter, and ozone, while ambient air temperatures changes could increase ground-level ozone and make wildfires (and their associated emissions) more common. These effects would exacerbate the effects to air quality already occurring under Alternative 4. Therefore, climate change would amplify the effects to air quality already occurring under Alternative 4 to minor adverse effects. Effects would be long-term in duration due to the ongoing nature of climate change, and large in extent depending on the size of wildfires and the distance pollutants would travel, along with the widespread effects air pollutants such as carbon dioxide, particulate matter, and ozone have on greenhouse gases in the atmosphere.

#### ***3.10.3.11 Alternative 5. Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)***

Under Alternative 5, the effects to air quality would be the same as those described under Alternative 2B. Potential adverse effects from the construction of WTC towers, structural downstream fish passages, AFFs, and Pacific Lamprey passage and infrastructure would be negligible to minor in the medium term and small in extent, and negligible to minor in the long term (recurring) and large in extent. Reservoir drawdowns would have negligible, **short-term** and long-term, recurring effects and would be small in extent. Under this alternative, spring reservoir drawdowns would not occur at Cougar Dam. Similar to Alternative 2B, total fish trucking mile would increase by 736 miles and emergency diesel generators would increase by seven new generators under Alternative 5. Alternative 5 would have the same general effect as all other alternatives.

##### *3.10.3.11.1 Near-Term Operations*

As discussed in Section 3.10.3.3.4, potential adverse short- or medium-term effects from near-term operations from the outplanting plan for the reintroduction of adult Chinook salmon above Green Peter Dam would be negligible in magnitude. Effects would be medium and/or large in extent because the release sites for trucked fish could potentially be located in various areas within the country or across the WRB. In addition, short- or medium-term effects from deep drawdown and RO prioritization at Lookout Point, Green Peter, and Cougar; delayed refill at Fall Creek, Foster, and Cougar; and extended deep drawdown and RO prioritization at Fall Creek would be negligible in magnitude at all dams. Effects would be small in extent because reservoir drawdowns would be confined to the project location.

##### *3.10.3.11.2 Climate Change*

As discussed in Section 3.10.3.4.1, climate change would potentially affect air quality within the WVS. More intense and frequent wildfires would release more air pollutants, such as carbon dioxide, particulate matter, and ozone, while ambient air temperatures changes could increase ground-level ozone and make wildfires (and their associated emissions) more common. These effects would exacerbate the effects to air quality already occurring under Alternative 5. Therefore, climate change would amplify the effects to air quality already occurring under Alternative 5 to minor adverse effects. Effects would be long-term in duration due to the ongoing nature of climate change, and large in extent depending on the size of wildfires and the distance pollutants would travel, along with the widespread effects air pollutants such as carbon dioxide, particulate matter, and ozone have on greenhouse gases in the atmosphere.

#### ***3.10.3.12 Conclusion***

In summary, all alternatives would potentially have the same general effect to air quality. All alternatives would include adverse, minor, short-term, medium-term and long-term effects. Alternatives 1 and 4 would also include beneficial, long-term, permanent, minor effects. Among all alternatives, the total fish trucking mileage and the number of generators would increase, thereby increasing associated air emissions. That said, none of the alternatives would exceed 50% of a federal or state standard. Therefore, all alternatives would generally have the same effect and maintain the relatively good air quality found throughout the WVS.

## 3.11 SOCIOECONOMIC RESOURCES

The analysis of socioeconomic resources identifies those aspects of the social and economic environment that are sensitive to changes and that may be affected by actions associated with structural and nonstructural changes to the dams, including installation of fish passages and spillway modifications, installation of water temperature control towers, and modifications to planned discharges throughout the Willamette Valley System (WVS). All the proposed structural measures and the vast majority of corresponding revenue flows would occur in Lane, Linn, and Marion counties. Social impacts, for example to quality of life and recreational and aesthetic values, would be experienced most by individuals, communities, residents, and workers in these counties, especially residents in areas or municipalities adjacent to the modified structures. Businesses, community services, and economic systems in these counties could change beneficially and adversely in response to the implementation of the Proposed Action and alternatives. Since potential impacts with the greatest magnitude, duration, extent, and likelihood would occur in Lane, Linn, and Marion counties, they are defined as the Region of Influence (ROI) for the analysis of direct and indirect socioeconomic impacts. Adjacent counties in the WVB – including Benton, Clackamas, Columbia, Multnomah, Polk, Washington, and Yamhill counties – are not included in the ROI as USACE does not intend to use local labor for construction activities and the socioeconomic conditions of these areas would likely not be substantially affected by the Proposed Action and alternatives.

While social impacts are addressed in this section, a discussion of those impacts that could disproportionately affect minority and low-income communities are discussed in the Environmental Justice section. Direct effects to visitation, revenue, and experience at the recreation areas throughout the WVS are discussed in Section 3.17, Recreation.

The data supporting this analysis were collected from standard sources, including federal agencies such as the U.S. Census Bureau (USCB), Bureau of Labor Statistics (BLS), and Bureau of Economic Analysis (BEA); state agencies such as the State of Oregon Employment Department (OED) and Oregon Office of Economic Analysis (OEA); as well as other research institutes. Demographic data are presented for Lane, Linn, and Marion counties and compared to the State of Oregon overall. The most recent and best available data are presented throughout the section. These data were grounded through site visits to each of the 13 dams and reservoirs within the ROI.

This section begins by describing the population growth, age, and housing for the ROI. Labor and employment – including the labor force, unemployment, and employment by industry for the ROI – as well as earnings – including per capita personal income and industry compensation – for the ROI are then discussed. Finally, the quality of life, including such as recreational and aesthetic values as well as community concerns, is described.

The demographics described in this section would be affected more or less according to whether or not local firms are hired during the government contract bidding process. The bidding process could also conclude with a combination of local and regional firms being selected. If all local firms using all local labor and machinery were selected, the most economic benefits to local communities would be realized. At the other end of the spectrum, if all contracts were awarded to regional firms using non-local labor and machinery, local economic benefits would still be realized, but to a lesser degree. This is because when all local firms are hired, the multiplier effect of income generally begins at the local level. In contrast, hiring all regional firms would generally result in the multiplier effect of income beginning at in a different area. The multiplier effect of income comes about because one entity's spending becomes another entity's income. For example, when a person spends money on a good or service, it creates income for a business who then pays their employees, who in turn buy goods and services themselves. Even if all regional firms were hired, local economies would still be stimulated in the short term while construction activities were taking place.

### 3.11.1 Population Growth and Age

Table 3. 11-1 shows past and current population data and future population estimates for Lane, Linn, and Marion counties and Oregon overall. Population estimates are sourced from the USCB American Community Survey and the Portland State University Population Research Center.

In all three counties as well as in the state overall, the population increased from 2010 to 2019. On average, from 2010 to 2019, Lane County grew 0.68 percent per year; Linn County 0.79 percent; and Marion County 0.86 percent; compared to the state of Oregon, which grew an average of 0.87 percent per year (see Table 3.11-11 below). In 2019, Lane County's population was the fourth largest in the state; Marion County ranked fifth; and Linn County ranked eighth (USCB 2019). From 2025 to 2035, the population in Lane County is projected to grow at approximately the same rate it grew from 2010 to 2019, respectively 0.68 and 0.67 percent annually (USCB 2010a; USCB 2015a; USCB 2019a; PSU 2021a). On average, Linn County is projected to grow 0.13 percent slower per year from 2025 to 2035 than it did from 2010 to 2019; and Marion County is projected to grow 0.11 percent slower per year, respectively (USCB 2010a; USCB 2015a; USCB 2019a; PSU 2021a). However, the state of Oregon is expected to grow 0.08 percent faster from 2025 to 2035 than it grew from 2010 to 2019 (USCB 2010a; USCB 2015a; USCB 2019a; PSU 2021b).

**Table 3.11-1. Population Growth**

| Location | Population | | | | Projected Population | | | |
|---|---|---|---|---|---|---|---|---|
| | 2010 | 2015 | 2019 | Average Annual Growth Rate (2010-2019) | 2025 | 2030 | 2035 | Average Annual Growth Rate (2020-2035) |
| Lane County | 351,715 | 357,060 | 373,340 | 0.68 | 397,742 | 412,045 | 424,423 | 0.67 |
| Linn County | 116,672 | 118,971 | 125,048 | 0.79 | 134,032 | 139,090 | 142,903 | 0.66 |
| Marion County | 315,335 | 323,259 | 339,641 | 0.86 | 369,983 | 385,366 | 397,723 | 0.75 |
| Oregon | 3,831,074 | 3,939,233 | 4,129,803 | 0.87 | 4,499,224 | 4,721,060 | 4,925,420 | 0.95 |

Source: USCB 2010a; 2015a; 2019a; PSU 2021a; 2021b.

Table 3.1-11-2 shows the age distribution of the population in Lane, Linn, and Marion counties as well as the state overall. In general, the populations of Lane, Linn, and Marion counties are about the same age as the state as a whole and differ by only 3 percent at the greatest across all age categories (USCB 2019b). Marion County has the youngest population of all counties in the ROI, with 1.8 percent more children under the age of five than Lane County and 3.9 percent more children between the ages of five and 19 than Lane County (USCB 2019b). Both Linn and Marion counties have higher proportions of their population younger than 5 and between 5 and 19 years than the state of Oregon (USCB 2019b).

**Table 3.11-2. Summary of Age Distribution (%)**

| Location | Under 5 Years | 5 to 19 Years | 20-44 Years | 45-64 Years | 65 and Older |
|---|---|---|---|---|---|
| Lane County | 4.9 | 16.9 | 34.5 | 25.0 | 18.8 |
| Linn County | 6.0 | 18.7 | 31.0 | 25.9 | 18.3 |
| Marion County | 6.7 | 20.8 | 33.1 | 24.1 | 15.3 |
| Oregon | 5.6 | 17.9 | 33.8 | 25.5 | 17.2 |

Source: USCB 2019b.

*Note: Numbers may not add up to exactly 100 percent due to rounding.

### 3.11.2 Housing

A housing unit refers to a house, an apartment, a mobile home or trailer, a group of rooms, or a single room occupied as separate living quarters, or if vacant, intended for occupancy as separate living quarters. Both occupied and vacant housing units are included in the total housing unit inventory. A housing unit is classified as occupied if it is the usual place of residence of a person or group of people; conversely, a housing unit is classified as vacant if it is not the usual place of residence of a person or group of people.

In Lane County, there are a total of 162,611 housing units, of which 93.7 percent are occupied. As such, the vacancy rate in Lane County is less than 7 percent. Linn County has the lowest number of housing units and vacancy rate of all counties within the ROI – 50,416 and 5.3 percent respectively. Marion County has 126,210 total housing units and a vacancy rate of 6.5 percent, the highest within the ROI. The vacancy rate in Oregon is higher than that of all counties in the ROI by at least 2.4 percent (USCB 2019c). Table 3.11-3 shows the total housing units, occupied housing units, and vacancy rates in Lane, Linn, and Marion counties and Oregon.

**Table 3.11-3. Housing Characteristics**

| Location | Total Housing Units | Occupied Housing Units | Vacancy Rate (%) |
|---|---|---|---|
| Lane County | 162,611 | 152,312 | 6.3% |
| Linn County | 50,416 | 47,762 | 5.3% |
| Marion County | 126,210 | 118,038 | 6.5% |
| Oregon | 1,768,901 | 1,611,982 | 8.9% |

Source: USCB, 2019c.

Fern Ridge Dam, Cottage Grove Dam, and Dexter Dam have at least 100 residential units in the immediate vicinity of the impounded reservoir (Google Earth 2020). Blue River Dam, Dorena Dam, Fall Creek Dam, Foster Dam, Lookout Point Dam, and Hills Creek Dam have at least 100 residential units within 1 mile of the structures and reservoirs (Google Earth 2020). No other structures within the WVS have substantial residential areas within 1 mile of the structure or its impounded reservoir.

### 3.11.3 Labor

Labor force and unemployment figures for the counties in the ROI are presented, as they are the most likely to be directly affected by the Proposed Action and alternatives.

#### *3.11.3.1 Civilian Labor Force*

The size of a county's civilian labor force is measured as the sum of those currently employed and unemployed. People are classified as unemployed if they do not have a job, have actively looked for work in the prior 4 weeks, and are currently available for work (BLS 2015). As shown in Table 3. 411-4, from 2010 to 2019, Lane County's labor force grew at the slowest rate within the ROI, 4 percent slower than the state as a whole. Although all counties within the ROI grew slower than the 6.4 percent growth rate of Oregon, the labor force of Marion County grew at 5 percent, faster than the other two counties within the ROI. Lane County added 4,194 persons to the labor force between 2010 and 2019, Linn County added 2,509 persons, Marion County added 7,507 persons, and the State of Oregon added 125,808 over this same period (BLS 2019a; 2019b; 2019c; 2019d). Table 3.11-4 shows the civilian labor force in Lane, Linn, and Marion counties and the State of Oregon for 2010, 2015, and 2019; as well as the growth rate of the labor forces for the aforementioned from 2010 to 2019.

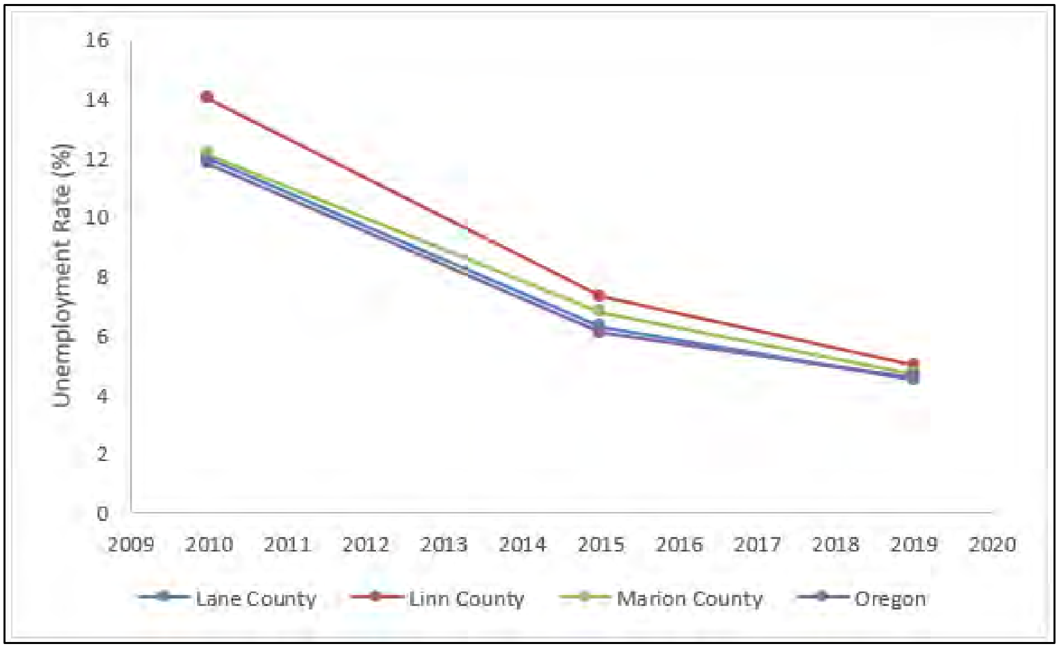
**Table 3.11-4. Civilian Labor Force, 2010-2019**

| Location | 2010 | 2015 | 2019 | Growth Rate of Labor Force (2010-2019) |
|---|---|---|---|---|
| Lane County | 177,650 | 170,048 | 181,844 | 2.4 |
| Linn County | 56,877 | 54,058 | 59,386 | 4.4 |
| Marion County | 151,234 | 148,376 | 158,741 | 5.0 |
| Oregon | 1,957,286 | 1,940,921 | 2,083,094 | 6.4 |

Source: BLS 2019a; 2019b; 2019c; 2019d.

#### *3.11.3.2 Unemployment*

The unemployment rate is calculated based on the number of unemployed persons divided by the labor force, where the labor force is the number of unemployed persons plus the number of employed persons. Figure 3.11-1 exhibits the annual unemployment levels in Lane, Linn, and Marion counties and the state overall for the years 2010, 2015, and 2019. Unemployment rates in all counties of the ROI are very similar to those of the state of Oregon; and both the ROI and state unemployment rates rose and fell with national trends. From 2010 to 2015, unemployment across the ROI and Oregon decreased from 5.3 to 6.7 percent, with unemployment in Linn County decreasing the most. Unemployment rates continued to decrease from 2015 to 2019.



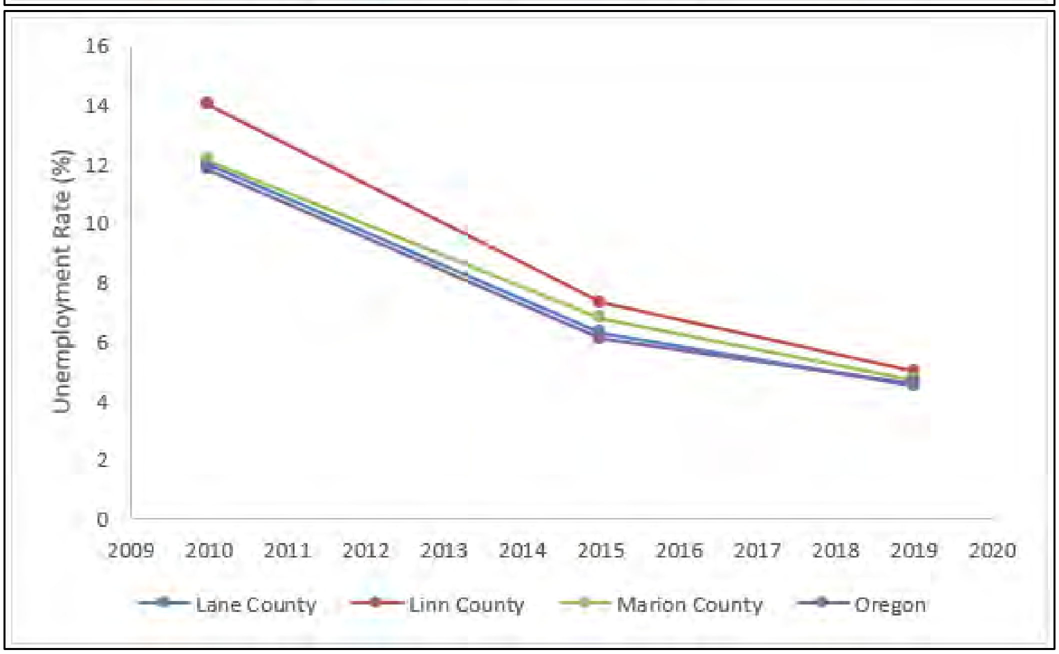




**Figure 3.11-1. Unemployment Rates (2010-2019)**

Source: BLS, 2019e; 2019f; 2019g; and 2019h.

### 3.11.4 Employment by Industry

Health care and social assistance, government, and retail trade employ the most people in Lane and Marion counties, whereas manufacturing, government, and health care and social assistance employ the most people in Linn County. Government employs 24,503 and 35,381 people in Lane and Marion counties, respectively; manufacturing employs 8,650 people in Linn County. Table 3. 11-5 shows the number of people employed by each industry in the ROI (OED 2019a; 2019b; 2019c).

**Table 3.11-5. Employment by Industry in the ROI, 2019**

| Industry | Lane County # Employed | Linn County # Employed | Marion County # Employed |
|---|---|---|---|
| Health Care and Social Assistance | 26,572 | 5,922 | 23,232 |
| Government | 24,503 | 6,498 | 35,381 |
| Retail Trade | 20,292 | 5,332 | 17,224 |
| Accommodation and Food Services | 15,737 | 3,419 | 11,914 |
| Manufacturing | 14,239 | 8,650 | 10,821 |
| Administrative and Waste Services | 8,673 | 1,833 | 8,156 |
| Construction | 7,430 | 3,237 | 10,928 |
| Other Services | 6,724 | 1,960 | 5,976 |
| Wholesale Trade | 6,189 | 1,670 | 3,755 |
| Professional and Technical Services | 5,811 | 931 | 4,465 |
| Finance and Insurance | 3,768 | 698 | 3,728 |
| Transportation, Warehousing, and Utilities | 3,492 | 3,071 | 5,148 |
| Management of Companies and Enterprises | 3,447 | 343 | 1,340 |
| Real Estate and Rental and Leasing | 2,572 | 466 | 1,821 |
| Information | 2,254 | 404 | 1,283 |
| Agriculture, Forestry, Fishing, and Hunting | 2,112 | 2,498 | 9,315 |
| Arts, Entertainment, and Recreation | 2,038 | 314 | 1,704 |
| Educational Services | 1,914 | 600 | 2,298 |
| Mining | 238 | 16 | 269 |
| Unclassified | 72 | 9 | 23,232 |
| **Total** | **158,077** | **47,872** | **158,839** |

Source: OED 2019a; 2019b; and 2019c.

### 3.11.5 Earnings

Several measures are used to describe earnings, including per capita personal income (PCPI), total industry income, and compensation by industry. Personal income data are measured and reported for the county of residence. PCPI, then, is the personal income for county residents divided by the county's total population. Compensation data, however, are measured and reported for the county of work location and are typically reported on a per job basis. Compensation data indicate the wages and salaries for work done in a particular place (e.g., a county), but if the worker does not live in the county where the work occurred then a sizeable portion will be spent elsewhere. These expenditures will not remain in or flow back into that county's economy. Total compensation includes wages and salaries as well as employer contribution for employee retirement funds, social security, health insurance, and life insurance.

### 3.11.5.1 Per Capita Personal Income

Personal income is the income received by a person from all sources. It is the sum of net earnings by place of residence, property income, and personal current transfer receipts or government social benefits (BEA 2016). This includes earnings from work, interest and dividends received, as well as government transfer payments, such as social security checks. It is measured before the deduction of personal income taxes and other personal taxes and is reported in current dollars.

Table 3.11-6 shows 2010, 2015, and 2019 annual PCPI for Lane, Linn, and Marion counties and the State of Oregon. All dollar estimates are in current dollars (not adjusted for inflation).

**Table 3.11-6 Per Capita Personal Income, 2010-2019**

| Location | 2010 | 2015 | 2019 | Average Annual Percent Change (2010-2019) |
|---|---|---|---|---|
| Lane County | $23,869 | $24,960 | $29,705 | 2.7 |
| Linn County | $22,165 | $21,706 | $27,345 | 2.6 |
| Marion County | $21,915 | $22,490 | $27,338 | 2.7 |
| Oregon | $26,171 | $27,684 | $33,763 | 3.2 |

Source: USCB 2010b; 2015b; and 2019d.

Note: All dollar estimates are in current dollars (not adjusted for inflation).

From 2010 to 2019, the PCPI grew at approximately 2.7 percent across the ROI, whereas the state's PCPI increased 3.2 percent over the same period. Similarly, all counties within the ROI had lower PCPIs than the state in 2010, 2015, and 2019.

### 3.11.5.2 Industry Compensation

The term "Total Industry Compensation", often used in economic data, is somewhat of a misnomer in that a portion of the "industry earnings" stems from government-related activity. For example, government and government enterprises account for 19.3 percent of total compensation of employees in Lane County; and government and government enterprises often account for a similar proportion of the compensation of employees in a county. Nevertheless, total industry compensation provides a good picture of the relative sizes of market-related economic activity, or business activity, performed in a county (Table 3.11-7). Income is generated by economic activity in the ROI through a variety of sectors, including various types of business as well as government. This income is not always received by a person living in the county; for example, a person from a neighboring county may cross county lines to go to work. The employee compensation by industry, however, is a measure of economic activity generated in the county, regardless of where the employee resides. The sources of economic activity in the ROI are shown below in Table 3.11-7.

**Table 3.11-7 Compensation of Employees by Industry in the ROI, 2019**

| Industry Description | Lane County Compensation ($000) | Linn County Compensation ($000) | Marion County Compensation ($000) |
|---|---|---|---|
| Government | 1,377,368 | 315,908 | 2,320,193 |
| Health Care and Social Assistance | 1,326,083 | 259,066 | 1,232,032 |
| Manufacturing | 764,321 | 533,490 | 494,078 |
| Retail Trade | 621,340 | 151,750 | 532,806 |
| Construction | 403,534 | 184,652 | 641,083 |
| Wholesale Trade | 357,999 | 93,317 | 229,618 |
| Professional and Technical Services | 337,681 | 53,078 | 300,056 |
| Accommodation and Food Services | 305,497 | 64,199 | 236,894 |
| Administrative and Waste Services | 291,019 | 58,773 | 271,990 |
| Finance and Insurance | 277,775 | 47,552 | 235,511 |
| Management of Companies and Enterprises | 241,715 | 29,355 | 95,323 |
| Other Services | 198,277 | 48,838 | 177,134 |
| Transportation, Warehousing, and Utilities | 161,035 | 145,217 | 296,052 |
| Information | 160,633 | 22,532 | 82,765 |
| Real Estate and Rental and Leasing | 103,058 | 15,410 | 74,624 |
| Agriculture, Forestry, Fishing, and Hunting | 90,145 | 109,374 | 310,361 |
| Educational Services | 69,066 | 25,356 | 92,170 |
| Arts, Entertainment, and Recreation | 39,433 | 5,374 | 33,214 |
| Mining | 14,800 | 779 | 18,626 |
| Unclassified | 4,159 | 332 | 3,337 |
| **Total Compensation of Employees** | **7,144,937** | **2,164,352** | **7,677,865** |

Source: OED 2019a; 2019b; and 2019c.

*Note: Numbers may not add to total due to rounding.

### 3.11.6 Quality of Life

Quality of life can be characterized as a person's well-being and happiness. According to USACE Quality of Life focuses on the extent to which objective human needs are fulfilled in relation to personal or group perceptions of well-being. For this analysis, quality of life considerations focus on those elements that the public generally associates with a high quality of life: education, safety, and could potentially be affected by the Proposed Action and alternatives: recreation opportunities, access to transportation facilities, and a positive general living environment, including aesthetic considerations. Other environmental factors, such as good ambient air quality and low ambient noise levels, could also contribute to a person's sense of quality of life.

#### *3.11.6.1 Recreational and Aesthetic Values*

The recreational value of natural resources can link residents to an area or attract new residents to an area. Environmental amenities such as reservoirs within the WVS contribute to the region's identity, culture and quality of life. Proximity to nature, in particular to public lands such as parks, beaches, national forests, and reservoirs throughout the WVS can influence where people choose to live and how much people are willing to pay for housing (i.e., property values). Research indicates that people make regional housing and labor market decisions based in part on the availability of and proximity to public lands, such as state parks, national forests, recreational lakes, etc. Living near public lands protecting natural habitats provides amenities such as convenient access to recreation and wildlife viewing. Population movement and migration into environmentally desirable areas can be explained by the presence of, and density of, natural resources and associated environmental amenities (Garber-Yonts 2004; Hand et al. 2008).

Landscape appearance and scenery can be important public land amenities, not just as recreational opportunity settings, but also as elements of the region's identity. Factors such as clean air and water, scenery and natural landscape, open space, and the number and proximity of recreational opportunities can be economic assets for local communities. Lane, Linn, and Marion counties foster community health by investing in parks, trails, and open spaces (Lane County 2018; Linn County 2008; Marion County 2010). A more detailed description of recreation opportunities in and around the project area is included in Section 3.14.

#### *3.11.6.2 Community Concerns*

During the scoping process, a number of concerns were expressed by residents of the ROI relating to socioeconomic resources, including impacts on the availability of water for agriculture and/or growing townships and potential impacts to the flood risk management capacity of the system as a whole. Within Lane County specifically, top general priorities for residents identified in a 2019 community needs survey included addressing housing shortages and rising rent prices, shelter space for the rising homeless populations, basic needs (bus passes, gasoline, identification, etc.) for the low-income population and domestic violence shelters and assistance (Lane County HHS 2019). Linn County is largely comprised of small rural communities which are increasingly concerned with water availability for crops and increased wildfire prevalence (Lacobazzi 2021). During scoping, the Marion County Board of Commissioners expressed great concern over lower water levels at Detroit Reservoir which could potentially reduce its recreational value; approximately 70 percent of the jobs in the Detroit Reservoir area are reliant on recreational use of the reservoir (USACE 2019f). Water quality and supply issues are also major concerns of residents of Marion County.

### 3.11.7 Environmental Effects

The effects analysis for socioeconomic resources evaluates the social and economic effects, both adverse and beneficial, of the construction, operation, management, rehabilitation, and replacement of structural measures and the alteration of reservoir outflows and water levels under the NAA and the action alternatives. The discussion includes the methodology; a summary of the effects; the effects by measure(s) that would affect socioeconomic resources; and a detailed analysis for each alternative.

#### *3.11.7.1 Methodology*

Potential effects to socioeconomics were evaluated both quantitatively and qualitatively for Lane, Linn, and Marion counties. The ROI is defined in the Affected Environment for this section as Lane, Linn, and Marion counties because this area is most likely to be affected by the alternatives.

1. Quantitative Analysis – Uses USACE National Economic Development (NED) modelling methods and USACE Regional Economic System (RECONS) to estimate the regional changes in employment, earnings, and total economic value which would result from changes in recreational visitation.
2. Qualitative Analysis – Considers how the proposed measures could affect labor and earnings; population and housing; low-income populations; recreational value and quality of life; irrigation, municipal and industrial, and hydropower production; and the non-use and existence value of the ESA-listed species. It also includes grounding of analysis through site visits and public outreach and engagement.

#### *3.11.7.2 Quantitative Analysis*

Several impact categories – including those associated with recreation (Section 3.14) and hydroelectric power generation (Section 3.12) – were modelled in order to quantify potential effects where possible. Average annual monetary benefits attributable to recreation alone were prepared using hydrographic inputs and USACE NED modelling methods (see Section 3.14 and Appendix K for detailed explanations of NED modelling). Monetary recreational benefit changes were then used as inputs in the USACE Regional Economic System (RECONS) to estimate the regional changes in employment, earnings, and total economic value which would result from changes in recreational visitation. RECONS is a proprietary USACE input-output modelling methodology that allows for the estimation of changes in economic contributions from a given investment (see Section 5.1 of Appendix K for a detailed explanation of RECONS methods). Changes in visitation due to alterations in recreational values associated with increased fish passage, habitat value, and reservoir levels would have indirect and induced effects that are reflected in the model results; they are incorporated below into the socioeconomic effects analysis.

#### *3.11.7.3 Qualitative Analysis*

Relevant case studies, understanding of common revenue or cost flows, and professional judgement concerning impacts typically associated with construction at dams and reservoirs were used to develop the evaluation criteria (discussed in the next section) and determine socioeconomic effects from the proposed measures in this PEIS. Effects to labor income, economic activity, or annual employment and therefore to population, community services (e.g., schools), and housing from the construction expenditures were modeled and are analyzed quantitatively, qualitatively, and programmatically in this Draft PEIS. Modelling results for construction spending economic activity stimulus are shown throughout Appendix I, “Socioeconomics.”

For water supply effects, ResSim flow data at the control points (river gages) downstream of dams and on the mainstem was used to compare flows between the action alternatives and the no action alternative to quantitatively assess impacts to live flow water rights downstream of the dams. Non-exceedance plots shown in Appendix J, “Water Supply”, Chapter 4, “Physical Effects Analysis” are used to illustrate the general trends between action and no action alternatives. As stated in Appendix J, “Water Supply”, Section 3.2” Data Collection and Preparation”, the effects to M&I water supply agreements and irrigation water service contracts were assessed by evaluating the amount of water stored system-wide in the conservation pool by mid-May, at a 75% non-exceedance level. A reliable method to compute NED monetary effects on M&I and irrigation water supply is yet to be determined as of this writing but is anticipated to be prepared for the Final EIS.

USACE uses ER 1105-2-100 and the Institute for Water Resources Handbook on Applying social effects analysis to evaluate qualitative impacts for this project. This includes looking at potentially impacted communities through basic social statistics, social vulnerability and resiliency indicators, social connectedness, economic vitality, leisure and recreation, participation and health and safety. These seven factors are used to formulate a complete qualitative analysis for socioeconomic impacts in the ROI.

The community could experience direct, indirect, or induced economic effects from employment and wages as a result of construction, operation, and maintenance of structures associated with the alternatives; and from differing utility rates, municipal and industrial (M&I) water supply, and irrigation water supply. Additionally, the quality of life for area residents (including low-income populations) and visitors could be affected due to traffic, noise, and emissions associated with construction activities and visual effects from drawdowns. Projected population increases as they relate to housing and quality of life are based on the number of direct jobs anticipated during the construction and operation phases. This section attempts to capture the effects to various community members competing for uses of the water and reservoir; as well as how society might value the very existence of the evolutionarily significant units (ESUs) and distinct population segments (DPSs) for the UWR Chinook salmon and UWR steelhead (respectively) with and without these proposed measures.

#### *3.11.7.4 Evaluation Criteria*

The magnitude of effects is determined using both the quantitative and qualitative portions of the analysis described above, as appropriate. Construction expenditures were also modelled for this Draft PEIS with results being displayed for each of the action alternatives beginning in sub-section 3.11.7.8. Most of the proposed measures (e.g., maintain revetments using nature-based methods, install gravel below dams) would not directly affect visitation; in these cases, the effects were analyzed qualitatively. Effects from changes in flow and reservoir levels that would affect visitation are discussed both qualitatively and quantitatively under each alternative, including the average annual NED recreational benefits, support of jobs, and the added value to the economy.

Evaluation criteria specific to socioeconomic resources, which capture the magnitude, duration, and extent of the potential effect, are provided in the below Table 3.11-8. These criteria are applied to each subcategory of socioeconomic resources relevant to this project (e.g., population and housing, quality of life) identified within the pathway analysis. All effects associated with each alternative are then considered in order to arrive at an overall conclusion for the alternative. The estimated beneficial effects of construction spending induced economic activity are considered to be major across all action alternatives, with total (direct + secondary) jobs supported low values of 7,400, 8,300, and 10,000 (Alt 3B), and high values of 25,900, 38,200, and 34,400 (Alt 1) at the local, state, and national level, respectively.

**Table 3.11-8. Evaluation Criteria for Potential Adverse and Beneficial Effects**

| Effect Factor and Scale | Definition |
|---|---|
| **Magnitude** | |
| Negligible | No appreciable change or measurable effect on the ROI's population and housing; economic activity, labor income, or annual employment; water supply; or quality of life. |
| Minor | A small but noticeable change to population and housing; economic activity, labor income, or annual employment; water supply; or quality of life in the ROI. Change in population would increase demand on housing, but would continue to operate below capacity. |
| Moderate | A substantive and apparent change to population and housing; economic activity, labor income, or annual employment; water supply; or quality of life in the ROI. Change in population would cause available housing to reach capacity. |
| Major | A significant and marked change in population and housing; economic activity, labor income, or annual employment; water supply; or quality of life in the ROI. The change in resident population would cause existing housing to be over capacity. |
| **Duration** | |
| Short Term | Less than the duration of a small construction project and/or is continuous for less than two years. |
| Medium Term (limited or intermittent) | Limited to the duration of large construction projects and/or is continuous for a period of two to five years. |

| Effect Factor and Scale | Definition |
|---|---|
| Long Term | Permanent or lasts continuously beyond operation changes or the completion of all projects or changes which recur either intermittently or at regular intervals annually. |
| **Extent** | |
| Local | Effects would be confined to the dam/reservoir. |
| Regional | Effects are perceived throughout a single county, multiple counties, or the entire WVS. |
| Statewide | Effects are perceived throughout the entire state. |

#### *3.11.7.5 Measures Analyzed for Socioeconomic Resources*

All measures other than adaptation of hatchery programs (#719) could potentially affect socioeconomic resources directly or indirectly.

The following measures would require the construction, modification, and/or operation and maintenance of structural facilities:

- Gravel augmentation below dams (#384)
- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)
- Maintenance of existing and new fish release sites above dams (#726)
- Operation, Maintenance, Repair, Replacement and Rehabilitation
- Foster Fish Ladder Temperature Improvement (#479)
- Construct water temperature control tower (#105)
- Structural improvements to reduce total dissolved gas (#174)
- Restore upstream and downstream passage at drop structures (#639)
- Construct adult fish facility (#722)
- Provide Pacific lamprey passage and infrastructure (#52)
- Construct structural downstream fish passage (#392)
- Use regulating outlets for temperature management (#166)
- Continued Operation of Existing Adult Fish Facilities

The following measures would alter flows and reservoir levels:

- Fall Creek drawdown
- Augment instream flows by using the inactive pool (#718)

- Augment instream flows by using the power pool (#304)
- Integrated temperature and habitat flow regime (#30a)
- Refined integrated temperature and habitat flow regime (#30b)
- Deeper fall reservoir drawdowns for fish passage (#40)
- Spring reservoir drawdown for downstream fish passage (#720)
- Use spillway for surface spill in summer (#721)
- Pass water over spillway in spring for fish passage (#714)
- Reduce minimum flows to Congressionally authorized minimum flow requirements (#723)

A summary of the socioeconomic effects discussed in the sections below is provided in Table 3.11-9. Note that where a range of potential effects would occur, the most severe magnitude of adverse effects and the lesser magnitude of beneficial effects for each alternative was listed in this table. For example, if there is a range of minor to moderate adverse effects, moderate adverse effects are included in the table. If beneficial effects would range from minor to moderate, the table includes minor beneficial effects. Said otherwise, the most conservative conclusions of potential effects are presented in the table below in order to avoid overstating potential beneficial effects and understating adverse effects. Also, the extent of effects reflected in the below is the largest extent that occurs under an alternative, even if the most severe adverse effect or the lesser beneficial effect is localized. This follows the approach to present the most conservative conclusions in this table. Discussion of all adverse and beneficial effects are included below.

### Table 3.11-9. Summary of Effects to Socioeconomic Resources Under Each Alternative

| Effect Factor | Alternative | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NAA | 1 | 2A | 2B | 3A | 3B | 4 | 5 |
| | Short-Term | | | | | | | |
| Magnitude | Negligible adverse and beneficial | Moderate adverse; minor beneficial | Minor to moderate adverse; negligible to minor beneficial | Minor to moderate adverse; negligible to minor beneficial | Major adverse; negligible beneficial | Major adverse; negligible beneficial | Moderate adverse; minor beneficial | Minor to moderate adverse; negligible to minor beneficial |
| Extent | Regional | Regional | Regional | Regional | Regional | Regional | Regional | Regional |
| | Medium-Term [1] | | | | | | | |
| Magnitude | Negligible adverse and beneficial | Moderate adverse; minor (non-monetary)/major (monetary) beneficial | Minor adverse; negligible to minor (non-monetary)/major (monetary) beneficial | Minor adverse; negligible to minor (non-monetary)/major (monetary) beneficial | Negligible adverse and beneficial (non-monetary)/major (monetary) | Negligible adverse and beneficial (non-monetary)/major (monetary) | Moderate adverse; minor beneficial (non-monetary)/major (monetary) | Minor adverse; negligible to minor (non-monetary)/major (monetary) beneficial |
| Extent | Regional | Regional | Regional | Regional | Regional | Regional | Regional | Regional |
| | Long-Term (Permanent, Intermittent, or Recurring) | | | | | | | |
| Magnitude | Major adverse | Minor adverse; negligible beneficial | Minor to moderate adverse; negligible beneficial | Minor to moderate adverse; negligible beneficial | Major adverse; negligible beneficial | Major adverse; negligible beneficial | Minor adverse; negligible beneficial | Minor to moderate adverse; negligible beneficial |
| Extent | State-wide | Regional | Regional | Regional | Regional | Regional | Regional | Regional |
| Duration Type | Permanent | Recurring | Recurring | Recurring | Recurring | Recurring | Recurring | Recurring |

[1] Most monetary construction expenditure induced benefits would be realized in the medium term while construction is taking place. Therefore, both monetary (spending induced) and non-monetary (public quality of life) benefit descriptions are included in the medium term section of the table in order to avoid diluting the non-monetary benefits.

In the following subsections, the effects are discussed for the measures analyzed in the alternatives; No Action Alternative; and for each of the action alternatives.

#### *3.11.7.6 Discussion of Effects by Measure(s)*

The magnitude of effects for socioeconomic resources is highly contingent upon the timing and amount of capital expenditures. General trends in population and employment changes would be similar for similar types of measures. As such, this analysis outlines the general pathway (i.e., cascading direct and indirect socioeconomic effects stemming from the implementation of measures) that would occur. In order to avoid redundancy between analyses, measures with similar effect pathways are grouped together and fall into one of two categories: (1) those that would require the construction, modification, operation and maintenance of structural measures or (2) those that would alter flows and reservoir levels.

##### *3.11.7.6.1 Construction, Operation, Management, Rehabilitation, and Replacement of Structural Measures*

This section discusses general, qualitative effects on socioeconomic resources from construction at the programmatic level. Site-specific project details for each construction measure will be determined during the implementation phase. Subsequent tiered NEPA documents would discuss detailed site-specific effects.

Construction, modification, operation and maintenance of 13 structural measures listed above in 3.11.2.3) would adverse and beneficial effects on labor and earnings; population and housing; recreational value; quality of life for local residents; and low-income populations in the short and medium term. The provision of capital expenditures and indirect and induced effects of resulting revenues in the short and medium term would stimulate economic growth within the ROI and have negligible to minor beneficial effects on labor and earnings in the short term and major benefits in the medium term. Any increase in population would be small and housing would be available to meet this increased demand and as such effects would also be negligible to minor. Although reduced recreational values are a substantial source of public concern associated with the project, given the scale and duration of individual projects, substantial adverse impacts to recreational quality from construction disturbance would not occur. As such, the recreational value of reservoirs as well as the quality of life for local residents would be reduced and have negligible, adverse effects for the duration of the construction period(s). In the long term, improved habitat value would increase recreational fishing and visitation and have minor, beneficial, indirect effects on the recreational value of reservoirs. Low-income populations would experience negligible to minor health benefits through economic pathways in the short-and medium term if they are hired as construction workers, but could also experience negligible to minor adverse health effects from air emissions and noise at the job site; these benefits would only persist in the long term if they are hired for maintenance and operation. In the long term, structural improvements and their continued maintenance would have indirect, beneficial effects on the recreational experience and could increase recreational visitation and expenditures. Implementation of the structural measures would benefit or increase the existence value of the ESA-listed species, or the amount the average citizen is willing to pay to avoid jeopardizing the continued existence of ESA-listed species.

**Labor and Earnings**

Construction and maintenance of structural measures would provide economic benefits through direct expenditures to local firms and labor, indirect benefits through expenditures of employees at retail establishments, and induced benefits as those revenues stimulate consumer demand throughout the ROI. Although the majority of the construction labor would be sourced from specialized contractors located outside the ROI, these revenues would likely result in the support of a relatively small number of construction and maintenance jobs sourced from within the ROI for the duration of the construction period. While the majority of the construction labor would be sourced from specialized contractors located outside the ROI, it is assumed that most would commute to project sites daily and a small proportion of these workers would relocate to the ROI (effects to population are discussed below). Construction and maintenance materials would be sourced from local vendors whenever possible and would likely contribute to the indirect support of jobs within the area. Spending of construction and maintenance workers employed on the project would also likely increase revenues at local retail stores and restaurants during the construction period, resulting in induced (i.e., third-order) economic benefits.

The direct, indirect, and induced effects of increased revenues would commensurately increase consumer demand for the duration of the construction period. The expenditures and their associated effects would occur in the short- and medium-term and are not likely to persist beyond the construction period other than the potential support of a small number of maintenance jobs associated with the constructed works of improvement. The magnitude of the benefit is contingent upon the level of expenditure associated with a given measure; larger expenditures will generate substantially larger direct, indirect, and induced economic effects. Capital and design expenditures range from approximately $500million to over $2.6 billion under the various alternatives. Beneficial effects would be major in the medium term, while construction activities are taking place, depending on the amount of the capital expenditure.

**Population and Housing**

As mentioned above, the majority of the construction labor would be sourced from specialized contractors located outside the ROI. It is assumed that most of these construction workers located outside of the ROI would commute to project sites daily, and a small proportion of these workers would relocate to the ROI. Any increase in resident population change would likely be small, and would decrease housing vacancy, but all would continue to operate below capacity. The average vacancy rate in the ROI is six percent. This translates to approximately 21,100 available housing units in Lane, Linn, and Marion counties (USCB 2019c). While it is difficult to estimate the exact level of in-migration for the construction activities, the ROI would likely have housing available to fill any increased demand. As such, effects on population and housing would be negligible to minor in the short and medium term.

**Recreational Value**

During the construction and maintenance activities, increased noise, visual presence of heavy equipment and personnel, and increased emissions would degrade the recreational value of reservoirs and decrease visitation and associated expenditures from current levels. Recreational users contribute to the economy of the ROI through the expenditure of funds in support of their activity of choice, such as specialized sporting equipment, licensing, hiring of guides, fuel, food, and lodging. Construction-related activities using heavy equipment generate relatively high levels of noise and emissions while in use and would be a visual disturbance when present in natural recreation areas such as reservoirs. Indirect, adverse effects could also occur to the quality of recreational fishing in reservoirs and on rivers for some species due to increased turbidity from suspended sediment associated with construction measures. As a result, adverse effects to recreational quality would range from negligible to moderate in the immediate vicinity of the work area for the duration of the given action, and reduce both the number of visitors and their corresponding expenditures (See Section 3.14 for a comprehensive discussion of effects to recreation). Effects would occur in the short and medium term for construction of structural measures. Major maintenance and rehabilitation projects would last longer than two years (i.e., occur in the medium term) and are expected to occur intermittently over the period of analysis for this PEIS.

Although these works of improvement have been specifically designed to meet the requirements of ESA-listed species, their populations would not return to a level that would allow for the re-opening of recreational fisheries. However, other species including those within recreational fisheries would also benefit from improved habitat value. Angler satisfaction is highly correlated with catch sizes and rates (Beardmore et al. 2015), both of which would likely increase in response to improved recreational habitat within the ROI. Water quality improvements resulting from these works would similarly improve recreational qualities and visitation throughout the ROI. As a result, recreational fishing use and visitation within the ROI would likely increase in the long term, providing increased licensing, retail, and travel revenues for the life of the project. These minor, beneficial effects would be indirect because they would be caused by the action and would occur later in time or be farther removed in distance, but still be reasonably foreseeable.

**Quality of Life**

Amongst the thirteen WVS reservoirs, nine are less developed than the others. These include Big Cliff, Blue River, Cottage Grove, Cougar, Dorena, Fall Creek, Green Peter, Hills Creek, and Lookout Point. While there are no cities directly on their shores, many have shorelines with at least some residential development. The other four reservoirs of Detroit, Dexter, Fern Ridge, and Foster have the towns of Detroit, Lowell, Veneta, and Sweet Home on their shores, respectively, which range from populations of 1994 to nearly 10,000. These reservoirs would continue to be slowly developed.

The same factors which degrade recreational quality would similarly be nuisances to local residents, reducing the overall quality of life. Construction and/or structural modification projects would increase air emissions at and near the project site due to project worker commutes and the transport of heavy equipment to and from the dam/reservoir via heavy trucks. Similarly, increased noise levels and visual intrusions would occur from equipment, machinery, and human activity during the construction period, and could disturb nearby residents. Use of local roadways during work periods for transport of workers and materials would temporarily increase traffic levels and average length of transit for nearby communities and could reduce resident access to community resources such as places of worship, recreational facilities, and healthcare. However, effects would be confined largely to the immediate vicinity of project sites during work periods. Negligible to moderate adverse effects would occur in the short and medium term to the quality of life or physical health and well-being of local residents – especially in the towns of Detroit, Lowell, Veneta, and Sweet Home at Detroit, Dexter, Fern Ridge, and Foster Dams, respectively.

In the long term, air emissions, traffic, and noise disturbances from operation and maintenance activities would not affect the quality of life of nearby residents. As discussed in Section 3.23 (Visual Resources), erection of these new structures would not drastically alter any of the basic design elements in the landscape; they would be seen but would not attract attention and would not dominate the landscape and as such would have negligible to minor, adverse effects.

**Low-Income Populations**

Effects that could disproportionately affect minority communities and Tribes are discussed in the Environmental Justice section. As described in Section 3.20.1, low-income populations were not identified as Environmental Justice populations as per EO 12898. However, potential effects to low-income populations are described briefly here in response to public comments. Within Lane County specifically, top priorities for residents identified in a 2019 community needs survey included addressing housing shortages and rising rent prices, shelter space for the rising homeless populations, basic needs (bus passes, gasoline, identification, etc.) for the low-income population and domestic violence shelters and assistance (Lane County HHS 2019).

If low-income populations in Lane, Linn, and Marion counties are hired to work on these projects, they could experience negligible to minor health benefits through economic pathways in the short and medium term. Jobs and income are strongly associated with a number of beneficial health outcomes such as an increase in life expectancy, improved child health status, improved mental health, and reduced rates of chronic and acute disease morbidity and mortality (HDA 2004; Cox et al. 2004). There may also be negligible to minor adverse effects to the physical health and well-being of low-income communities (from increased air emissions and noise levels) that are hired to work at the sites for the duration of these projects. Once construction is complete, workers would not be on-site and therefore there would be no long-term health effects. Benefits would only persist for the duration of the construction and infrastructure improvement phases with only a small number of permanent maintenance jobs created; therefore, long-term beneficial effects would be negligible. The magnitude of the benefit is contingent upon the effect to labor and income, which as discussed above, is contingent upon the level of expenditure associated with a given measure. Larger expenditures will generate substantially larger direct, indirect, and induced economic effects and therefore larger economic effects on low-income populations. Capital and design expenditures range from approximately $500 million to over $2.6 billion under the various alternatives.

As mentioned above, the ROI may experience a small increase in population and decreased housing vacancy in the short and medium term, but housing would still operate below capacity. The vacancy rate in Lane, Linn and Marion counties is 6.3, 5.3, and 6.5 percent, respectively. This translates to roughly to 10,245, 2,672, and 8,204 available housing units (USCB 2019c). Approximately 50 percent of these units are considered affordable housing (State of Oregon 2022). As such, the short- and medium-term construction projects should not affect any ongoing housing shortages for low-income populations and are not discussed further.

Oregon now has rent control that limits rent increases for existing tenants. Rent cannot be increased during any 12-month period above the existing rent in an amount greater than 7% plus the consumer price index from the previous calendar year (OSB 2019). Furthermore, as discussed above, any in-migration from the construction of structural measures would not likely be substantial. This in-migration should not affect the availability of general or affordable housing within the ROI, is not expected to increase rents in the short or medium term; and therefore, is not discussed further.

As such, both beneficial and adverse effects on low-income populations would be minor in the short and medium term, with the possibility of greater medium term economic activity benefits if local firms are awarded construction contracts. Negligible long-term effects are anticipated.

##### *3.11.7.6.2 Alteration of outflows and reservoir levels*

The ten measures listed in Section 3.11.2.3 would alter flows and reservoir levels, decreasing recreational values, the quality of life of nearby residents, visitation, and the amount of usable water for M&I and irrigation purposes. Reservoir drawdowns would indirectly reduce recreational and agricultural revenues and their resulting induced effects to consumer demand throughout the ROI in the short term and recur in the long term. The magnitude of effects to recreational value would range from minor to major and would be regional in extent. Effects to agricultural revenues would range from negligible to major and be regional in extent. The magnitude for both recreational value and agricultural revenue under each alternative would depend on the number of drawdowns; effects to agricultural revenue would be especially sensitive to the timing of the drawdowns.

In the long term, improved habitat value throughout the region would benefit other fish species in addition to the UWR Chinook salmon and the UWR steelhead, and have indirect, minor benefits to the quality of recreational fisheries and the recreational experience throughout the ROI. Measures that augment instream flows and the integrated temperature and habitat flow regime would improve water quality and also benefit recreational qualities and visitation throughout the ROI. Conversely, the reduction of minimum flows to Congressionally authorized minimum flow requirements (#723) would allow reservoirs to fill more quickly, thereby improving recreational values, visitation, and their ability to supply water for other uses. This measure would generate negligible to minor beneficial socioeconomic effects through indirect and induced revenues associated with recreational use and agricultural without substantially affecting recreational fisheries in the long term. None of the considered outflow measures would substantially affect utility rates due to the relatively low proportion of power provided by WVS to the BPA.

**Recreational Value**

Reservoir drawdowns would reduce water levels and substantially decrease recreational use and the recreational value of the reservoir, indirectly affecting socioeconomic resources throughout the ROI. The change in average annual visits, percent change in total annual benefits, and magnitude of effects from reservoir drawdowns are presented under each alternative in Section 3.14 (Recreation). The full results of the modeled visitation estimates are included in Appendix K – Recreation Technical Report. As discussed at length above, recreational users contribute to the economy of the ROI through the expenditure of funds in support of recreational activities and result in induced effects through increased retail revenue streams. These short- and long-term recurring adverse effects would range from minor to major and be regional in extent. The magnitude of effects under each alternative would depend on the number of drawdowns per year and the number of reservoirs at which they would occur. Effects would be major if they result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI.

Indirect effects from drawdowns to the quality of recreational fishing in reservoirs and on rivers for some species due to increased turbidity from suspended sediment could occur in the short-term and recur in the long-term. In the long term, reservoir drawdowns would improve downstream riverine habitat quality for ESA-listed fish species, recreational fisheries, and water quality throughout the ROI. It is important to note that reservoir visitation provides a far greater proportion of recreational revenues within the ROI than riverine visitation.

**Irrigation, M&I Use, and Hydropower Production**

Drawdowns would affect socioeconomic resources due to the decrease in water available for the other authorized uses: agricultural irrigation, M&I use, and hydropower production. WVS water reservoirs allocate water proportionally based on the authorized uses of the structure. Based on the recommendation in the Willamette Basin Review Feasibility Study Chief's Report, Congress reallocated the conservation storage space in the WVS of reservoirs from all joint-use storage to three specific authorized purposes – fish and wildlife (69%), agricultural irrigation (21%), and municipal and industrial water supply (10%).

Reservoir drawdowns in support of ESA-listed fish passage reduce the amount of water available for other authorized purposes, which in turn increase costs attributable to water supply to WVS water right holders throughout the ROI. M&I users are typically able to supplement water supply with purchases from other areas, however these purchases inevitably increase costs and can have reverberating adverse socioeconomic effects throughout ROI associated with general increases in the cost of living and doing business. In the long term, irrigation water rights holders may be unable to secure additional water rights. Those in the agricultural sector may ultimately be forced to fallow normally productive acreage or suffer extensive crop damages or losses without access to a consistent water supply during the summer irrigation season. See Section 3.13 for a comprehensive discussion of effects to water supply. The magnitude of adverse effects to irrigation and M&I use is contingent upon both the scale (i.e., the drawdown elevation) and timing of the drawdown. Spring drawdowns reduce the recharge ability of WVS system-wide and occur during periods of highest use for both agricultural irrigation and M&I purposes. Hence, spring drawdowns would result in major adverse socioeconomic effects from reduced water availability for agricultural irrigation and M&I purposes. Conversely, fall drawdowns would occur during periods with minimal WVS water use and would only result in negligible to minor socioeconomic effects. As such, adverse effects attributable to water supply would range from negligible to major in the short term and would recur in the long term.

Reservoir drawdowns may also reduce the economic viability of the WVS to generate hydropower. Water reductions from the power pool decrease the ability of WVS generators to produce sufficient wattage to outweigh the costs associated with the construction and maintenance of its requisite equipment and allocations (See Section 3.12 for a comprehensive explanation of hydropower effects.) However, it is unlikely that any drawdowns would measurably affect electricity prices within the ROI. Although reservoir drawdowns compromise the ability of WVS to generate hydropower and in turn lower revenues attributable to WVS reservoirs, BPA determines power rates through a formal evidentiary hearing process based upon the respective associated costs of generation and transmission throughout the entire BPA power grid (BPA No Date). Given that the WVS only provides some 2 percent of the total BPA generation capacity, it is unlikely that the reduced economic viability of WVS generators due to drawdowns would substantially or noticeably affect power rates and therefore socioeconomic resources in the ROI. There would be either no effect to socioeconomic resources as they relate to hydropower and therefore are not discussed further in this section.

Conversely, the reduction of minimum flows to Congressionally authorized minimum flow requirements (#723) would allow reservoirs throughout the WVS to fill more quickly in the long term, thereby improving recreational values, visitation, and their ability to supply water for other uses. These factors would have negligible to minor, beneficial effects for the life of the project through the same mechanisms and pathways discussed at length above. Recreational revenues and visitation would likely increase due to increased recreational quality of reservoirs, and agricultural and M&I reservoir streams would be largely unaffected as reservoirs would be able to fulfill their existing water right obligations.

**Quality of Life**

The loss of surface water during reservoir drawdowns would adversely affect the viewshed and therefore quality of life of nearby residents. Mudflats, substrate, tree stumps, and other submerged littoral zone attributes (submerged vegetation, roots, sediments, rocks, snails, shells, etc.) would also be revealed. There would be minor to moderate short- and long-term effects to the viewshed and therefore quality of life of nearby residents – especially in the town of Detroit, which is located on the shores of Detroit Dam and Reservoir. The town on Detroit is currently in the process of being rebuilt after it was destroyed in the 2020 Beachie Creek Fire. At the time, there were approximately 200 people living in the town. Over 50 percent of the population were forced to move away permanently after the fire, and today the population only numbers 72 (KGW 2022; USCB 2022). (The towns of Lowell, Veneta, and Sweet Home at Dexter, Fern Ridge, and Foster Dams would not be affected because drawdowns are not proposed at these locations under any of the alternatives). After the 3-week drawdown period, the viewshed would return to baseline conditions in the days to weeks that follow; and these effects would recur annually in the long term.

**<u>Suite of Near-Term Operations</u>**

Near-term operations that could affect socioeconomic resources include deep drawdowns, extended deep drawdowns, RO prioritization, and delayed reservoir refills for improved downstream fish passage. For reasons similar to those discussed above as they relate to recreational value; agricultural irrigation and M&I use; and quality of life, effects to socioeconomic resources would range from minor to major and adverse in the short term and long term (recurring). Recreational revenues and visitation would likely further decrease due to decreased recreational quality of reservoirs; costs to agricultural and M&I users would further increase due to reduced WVS water availability; and the loss or surface water and turbidity would adversely affect the viewshed for nearby residents for longer than three weeks.

The suite of near-term operations would also further augment fish spawning and rearing habitat, improve instream water quality by ensuring temperature and TDG control, ensure adequate streamflow for biologically justified flows, and improve fish passage. As such, the implementation of these near-term operations would have indirect, minor beneficial effects to the recreational value in the long term.

#### *3.11.7.6.3 Effects Common to All Measures*

Non-use and existence values of the UWR Chinook salmon and UWR steelhead would benefit from both the construction, operation, management, rehabilitation, and replacement of structural measures as well as those that alter outflows and reservoir levels. The larger purpose of all measures is to avoid jeopardizing the continued existence of these ESA-listed species; therefore, their existence values would generally be preserved.

**<u>Non-Use and Existence Values</u>**

The value assigned to natural resources by the public for purposes other than direct use is called non-use value and is well-documented in socioeconomic literature (Brookshire et al. 1983). There is value in knowing that UWR Chinook salmon and UWR steelhead exist, even for those who have never seen one or have no particular or vested interest in either species. The existence value of these species reflects the benefit people receive from knowing that it exists, or its intrinsic value.

In general, it is not possible to use market prices or other revealed preference methods (e.g., consumer behavior) to capture the existence value of the wild UWR Chinook salmon and UWR steelhead, which are genetically distinct from hatchery Chinook and steelhead and are not fished recreationally or commercially. As such, the concept of non-use or existence values are controversial, given the high variance in public opinion regarding protected species and the logistical difficulty of estimating their value. Typically, existence values are estimated using "stated preference" survey methods such as the contingent valuation. These surveys involve directly asking people, based on a specific hypothetical scenario and description of the environmental good or service, how much they would be willing to pay (WTP) for a positive change in that environmental good or service. These valuations provide an approximate monetary baseline for comparisons to other market effects.

Despite the cultural importance of salmon in the Pacific Northwest, there are few empirical economic studies quantifying and monetizing this importance to the general public in the region. There are many competing uses for Oregon's waters, and decision-makers are often faced with trade-offs on how to allocate resources to accommodate these uses. Many of these uses conflict with salmon preservation and to date there is not adequate information to quantify societal values for salmon conservation. In 2015, the EPA Western Ecology Division developed a stated preference nonmarket valuation study to estimate the general Oregon population's preferences and values to protect and restore Chinook salmon and winter steelhead populations in the Willamette Basin (Papenfus and Weber 2015). The results of this study have been requested and will be included in the FEIS, if provided. The magnitude of effects will also be added based on the results of this study. But regardless of the exact dollar value that people would be willing to pay to help preserve these species of salmon, implementation of all the proposed measures would help preserve the existence value of the UWR Chinook salmon and UWR steelhead and therefore have long-term, minor beneficial effects to society. Without these proposed measures, these species – or more precisely, their respective evolutionarily significant units (ESUs) and distinct population segments (DPSs) – could, quite literally, cease to exist in the WRB; the resulting loss of their existence values would be major and adverse.

It is important to note that implementation of the proposed structural and water management measures is not expected to increase UWR Chinook salmon and steelhead populations such that recreational and commercial fisheries for either species would be available in riverine or oceanic environments. Hence, implementing measures that would help avoid jeopardizing the continued existence of these ESA-listed species would have no effect directly on the other subcategories of socioeconomic resources (e.g., labor and earnings, agricultural irrigation, etc.) in the area.

### *3.11.7.7 No Action Alternative*

Under the NAA, current actions within the WVS and the conditions that would result from continued O&M would persist. Direct and indirect beneficial and adverse effects to socioeconomic resources from short- and medium-term construction measures would be negligible and localized or regional in extent. Effects in the short and long term (recurring) Fall Creek Drawdown would be minor and localized. This alternative would jeopardize the continued existence of the ESA-listed species and therefore have major effects in the long term if they no longer have an existence value because they cease to exist. The extent of these effects would be state-wide and beyond.

#### *3.11.7.7.1 Construction, Operation, Management, Rehabilitation, and Replacement of Structural Measures*

Under the No Action Alternative, short-term construction measures like maintaining or altering revetments (#9) and augmenting gravel below dams (#384), as well as medium-term, major rehabilitation measures would have negligible beneficial effects to labor and earnings. Labor trends – including employment by industry, per capita income, and compensation by industry – would ebb and flow in conjunction with prevailing market conditions within the ROI and the state of Oregon, but would likely continue to trend favorably when considered over the life of the project given standard assumptions of economic growth. The extent of effects to labor and earnings would be regional.

Population growth would continue along current growth trajectories as described in Table 3.11-1, less than 1 percent annually (PSU 2021a; PSU 2021b). Housing availability would continue to scale with population. Effects to population and housing would be negligible and the extent of effects would be regional.

Short- and medium-term construction measures would increase air emissions, noise levels, traffic, or visual disturbances at and near the project site (and therefore effects would be localized) and cause negligible, adverse effects to the physical health and well-being of workers (including low-income workers) hired to work at the project, as well as the quality of life of communities residing in the vicinity of the impacted reservoirs. Workers (including low-income workers) would also experience negligible health benefits through economic pathways. Any increases in air emissions, noise, and traffic would not be appreciable and have negligible effects on recreational value.

#### *3.11.7.7.2 Alteration of outflows and reservoir levels*

The Fall Creek Drawdown would continue to adversely affect the quality of life for nearby residents and the recreational value at Fall Creek. However, there are no cities directly on the shores of the Fall Creek Reservoir, therefore effects to the quality of life would be minor and localized. As discussed in Section 3.14.2.3 of the recreation section, the NAA is the baseline for which visitation estimates are made, therefore there would be no effects to average annual visits or average annual benefits (and to recreational value). There would be negligible, regional, short- and long-term recurring effects to water supply from one drawdown occurring in the fall at one location.

#### *3.11.7.7.3 Effects Common to All Measures – Non-Use and Existence Values*

Measures under the NAA would not meet ESA obligations to avoid jeopardizing the continued existence of ESA-listed species. In the long term, the UWR Chinook salmon and UWR steelhead could cease to exist and therefore would not have an existence value. Society would not have the option to pay to protect the species and therefore effects would be major and occur state-wide and beyond.

#### *3.11.7.7.4 Climate Change*

As discussed in Appendices F1 and F2 (Qualitative Assessment of Climate Change Impacts and Supplemental Climate Change Information, respectively), climate change is expected to result in wetter winters (where more precipitation falls as rain rather than snow), less snowpack, drier summers, increased air and water temperatures, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB, independent of the O&M of the WVS over the next 30 years. These factors would contribute to indirect adverse effects to socioeconomic resources through decreased recreational quality and opportunity as well as ability to supply water to irrigation and M&I users.

As discussed in Appendix B, Hydrology and Hydraulics, higher winter reservoir inflows due to more precipitation falling as rain would not be stored until approximately February 1, when WVS reservoirs begin adhering to their rule curves. This would decrease the chance of reservoirs reaching the pool levels they had in previous years, which could shorten the recreational season, lower recreational opportunity, and the ability of reservoirs to provide agricultural irrigation and M&I water supply. Other trends would contribute to these adverse effects: less snowpack would decrease spring reservoir inflows, and drier, hotter summers (in terms of both air and water temperatures) would increase evaporation rates and further limit water quantity. Higher air and water temperatures, less water in river and reservoir systems, and more frequent and severe wildfires would contribute to decreased water quality from higher turbidity, elevated concentrations of contaminants such as mercury, and increased occurrence of HABs (which would decrease dissolved oxygen (DO) concentrations and could adversely affect fish habitat).

Under the NAA, the Fall Creek Drawdown would have minor effects on recreational value and the quality of life of nearby residents in the short term; these effects would recur in the long term. Decreased reservoir levels and water quality due to climate change would further decrease both the recreational quality of reservoirs and riverine resources as well as the visitation of recreational users, which would indirectly reduce recreational revenues throughout the economy of the ROI. Recreational activity within the ROI is largely dependent upon both water quantity and quality due to the prevalence of water-based activities such as boating, fishing, and swimming. Recreation contributes indirect socioeconomic effects in the forms of recreational visitor expenditures at local retail establishments in support of their activity of choice; recreational expenditures are a function of both the quality of recreational opportunities offered within a given area and the total amount of recreational visits. Decreased recreational quality and lowered visitation rates would decrease recreational expenditures throughout the ROI, thereby contributing indirect, adverse effects to socioeconomic resources. Climate change could exacerbate short-term effects from sediment transport during drawdowns, as increased wildfire ash, HABs, and erosion would further increase turbidity and water quality; affecting the recreational experience and visitation. The overall water level could be further reduced in the long term. As such, the Fall Creek Drawdown in combination with climate change would have minor to moderate effects to recreational value and the quality of life in the short term and recur in the long term. Effects would be localized and would only be felt at the Fall Creek Reservoir.

Under the NAA, adverse effects on water supply from the Fall Creek Drawdown would be negligible in the short term and would recur in the long term. Decreased reservoir levels and water quality due to climate change would further contribute indirect adverse effects through the difficulty of reservoirs to supply agricultural and M&I users with a reliable source of water. However, the Fall Creek drawdown occurs in autumn during periods with minimal WVS water use. As such, the Fall Creek Drawdown in combination with climate change would have negligible effects on water supply for agricultural and M&I users in the short and long term (recurring). The extent of effects would be regional and occur throughout the WVS.

Measures under the NAA would not meet ESA obligations to avoid jeopardizing the continued existence of ESA-listed species. Society would not have the option to pay to protect the species and therefore effects would be major if they cease to exist. Climate change could further exacerbate conditions and move up the timeline for the extinction of these DPS. As such, the NAA in combination with climate change would have even more severe adverse and major effects if the species' existence value is not preserved. Effects would occur state-wide and beyond.

#### *3.11.7.8 Alternative 1 – Storage-Focused Fish Passage Alternative*

Alternative 1 consists of structural improvements and alteration of reservoir outflows measures which maximize refill volumes of spring conservation pools at WVS reservoirs in support of improved survival of ESA-listed fish species in addition to all other authorized project purposes of the structures. Under Alternative 1, beneficial effects to labor and earnings and low-income populations due to construction expenditures for structural measures would be minor in magnitude, regional in extent, and occur in the short term, with major economic activity beneficial effects in the medium term while construction is occurring. These benefits would stem from large capital expenditures and increased water levels. Short- and medium-term adverse effects to population and housing would also be minor and regional. Adverse effects to quality of life and recreational value from construction would be moderate in magnitude in the short and medium term; and could be either localized or regional in extent. Long-term visual effects to quality of life from the erection of new structures would be minor. Beneficial, indirect effects to recreational value from construction measures and reduced flows would be minor in magnitude, regional in extent, and long-term. The alteration of outflows and reservoir levels would have beneficial, moderate effects on water supply in the short and long term. Preserving the existence value of the UWR Chinook salmon and UWR steelhead would have long-term, minor, beneficial effects to society in the state and beyond. Alternative 1 would have similar effects to socioeconomic resources as Alternative 4, and would have substantially more adverse short- and medium-term effects to labor and earnings and quality of life (and less adverse short and long-term recurring effects to recreational value and M&I use and irrigation) than Alternatives 2A, 2B, 3A, 3B, and 5.

#### *3.11.7.8.1 Construction, Operation, Management, Rehabilitation, and Replacement of Structural Measures*

The following measures would substantially increase construction expenditures within the ROI for the duration of the construction phase, resulting in beneficial and adverse socioeconomic effects through the mechanisms discussed in Section 3.11.4.2.1.

- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) (Basinwide);
- Gravel augmentation below dams (#384) (FOS, CGR, BLU, BCL);
- Maintenance of existing and new fish release sites above dams (#726) (LOP, FCR, HCR, CGR, FOS, GPR, BCL, DET);
- Foster Fish Ladder Temperature Improvement (#479) (FOS);
- Construction of WTC towers (#105) (LOP, GPR, DET);
- Structural improvements to reduce total dissolved gas (#174) (DEX, LOP, CGR, FOS, GPR, DET);
- Restoration of upstream and downstream passage at drop structures (#639) (FRN);
- Construction of AFFs (#722) (GPR);
- Provide Pacific lamprey passage and infrastructure (#52) (FRN, GPR);
- Construction of structural downstream fish passage (#392) (DEX, LOP, FOS, GPR, BCL, DET); and
- Operation, Maintenance, Repair, Replacement, and Rehabilitation (All reservoirs).

**Labor and Earnings**

Construction and design expenditures associated with Alternative 1 are expected to total approximately $42.4B over the life of the project; construction expenditures would be the second highest of the alternatives. Given the scale and duration of construction activities proposed under Alternative 1, the direct, indirect, and induced effects of increased revenues could noticeably increase consumer demand for the duration of the construction period. As discussed above in Section 3.11.2.4.1, these expenditures would provide benefits through direct expenditures to local firms and labor, indirect benefits through expenditures of employees at retail establishments, and induced benefits as those revenues stimulate consumer demand throughout the ROI. However, these expenditures and their associated effects would not persist beyond the construction period other than the potential support of a small number of maintenance jobs associated with constructed works of improvement. These effects would occur in the short and medium term and the effects would be regional in extent.

**Table 3.11-10. Effects of Construction Spending Under Alternative 1**

| Area | Local Capture | Output | Jobs* | Labor Income | Value Added |
|---|---|---|---|---|---|
| **Local** | | | | | |
| Direct Impact | | $1,503,897,497 | 16931.5 | $1,194,676,738 | $674,381,700 |
| Secondary Impact | | $1,440,822,887 | 8921.6 | $482,915,809 | $823,366,932 |
| Total Impact | $1,503,897,497 | $2,944,720,384 | 25853.1 | $1,677,592,546 | $1,497,748,632 |
| **State** | | | | | |
| Direct Impact | | $1,556,941,658 | 17374.6 | $1,287,229,867 | $763,254,019 |
| Secondary Impact | | $1,932,626,691 | 10778.2 | $656,061,797 | $1,099,977,674 |
| Total Impact | $1,556,941,658 | $3,489,568,348 | 28152.8 | $1,943,291,663 | $1,863,231,694 |
| **US** | | | | | |
| Direct Impact | | $1,557,023,568 | 17375.4 | $1,307,603,687 | $782,868,065 |
| Secondary Impact | | $3,656,985,703 | 17014.2 | $1,136,087,229 | $1,963,692,328 |
| Total Impact | $1,557,023,568 | $5,214,009,271 | 34389.6 | $2,443,690,917 | $2,746,560,394 |

* Jobs are presented in full-time equivalence (FTE)

The estimated overall regional economic development impacts for Alternative 1 shown in Table 3.11-10 are explained by project in the following four paragraphs.

**Foster and Green Peter** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Foster and Green Peter are estimated to be $62,490,000. Of this total expenditure, $60,319,377 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $62,490,000 support a total of 995.9 full-time equivalent jobs, $61,912,920 in labor income, $50,750,618 in the gross regional product, and $106,390,923 in economic output in the local impact area. More broadly, these expenditures support 1,407.7 full-time equivalent jobs, $97,889,290 in labor income, $110,230,026 in the gross regional product, and $209,258,233 in economic output in the nation.

**Detroit and Big Cliff** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Detroit and Big Cliff are estimated to be $708,350,000. Of this total expenditure, $683,377,658 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $708,350,000 support a total of 11,537.7 full-time equivalent jobs, $779,881,320 in labor income, $669,962,926 in the gross regional product, and $1,321,467,789 in economic output in the local impact area. More broadly, these expenditures support 15,567.5 full-time equivalent jobs, $1,114,235,625 in labor income, $1,249,502,938 in the gross regional product, and $2,372,028,636 in economic output in the nation.

**Cougar and Blue River** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Cougar and Blue River are estimated to be $20,700,000. Of this total expenditure, $20,015,454 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $20,700,000 support a total of 350.7 full-time equivalent jobs, $22,005,883 in labor income, $20,458,695 in the gross regional product, and $39,937,721 in economic output in the local impact area. More broadly, these expenditures support 458.5 full-time equivalent jobs, $32,426,121 in labor income, $36,514,027 in the gross regional product, and $69,317,418 in economic output in the nation.

**Hills Creek, Lookout Point, Dexter, Fall Creek** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Hills Creek, Lookout Point, Dexter, and Fall Creek are estimated to be $765,500,000. Of this total expenditure, $740,185,008 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $765,500,000 support a total of 12,968.8 full-time equivalent jobs, $813,792,423 in labor income, $756,576,393 in the gross regional product, and $1,476,923,951 in economic output in the local impact area. More broadly, these expenditures support 16,955.9 full-time equivalent jobs, $1,199,139,881 in labor income, $1,350,313,403 in the gross regional product, and $2,563,404,984 in economic output in the nation.

**<u>Population and Housing</u>**

As discussed above in Section 3.11.2.4.1, given the current availability of approximately 21,100 housing units within the ROI (USCB 2019c), any small in-migration resulting from construction projects is not expected to substantially affect housing availability for current residents. As such, minor, adverse effects to population and housing would occur under Alternative 1. These effects would occur in the short and medium term and be regional in extent.

**Quality of Life and Recreational Value**

As discussed above in Section 3.11.2.4.1, work-related activities involving heavy equipment would cause visual and auditory disturbance to local residents and recreational users in the vicinity of the project areas, as well as reduce air quality from project-related emissions. Traffic levels would similarly increase during work periods but would be confined to the immediate vicinity of work sites and would not substantially reduce resident access to community resources or visitor access to reservoirs. Work-related noise, emissions, and congestion would reduce resident quality of life and recreational value during the construction phases only and have local, adverse, moderate effects in the short and medium term. Long-term visual effects from the erection of new structures would be minor.

Although these works of improvement have been specifically designed to meet the requirements of ESA-listed species, their populations would not return to a level that would directly affect recreational fishing. However, other species including those within recreational fisheries would also benefit from improved habitat value. Recreational fishing use and visitation within the ROI would likely increase in the long term and have minor, beneficial, indirect effects on the local recreational value of affected reservoirs.

**Low-Income Populations**

As discussed above in Section 3.11.2.4.1, if low-income populations in Lane, Linn, and Marion counties are hired to work on these projects, they could experience health benefits through economic pathways in the short and medium term. There may also be minor adverse effects to the physical health and well-being of low-income communities (from increased air emissions and noise levels) that are hired to work at the sites for the duration of these projects. Once construction is complete, workers would not be on-site and therefore there would be no long-term health effects. Benefits would similarly only persist for the duration of the construction and infrastructure improvement phases with only a small number of permanent maintenance jobs; therefore, long-term beneficial effects would be negligible. All effects would be regional in extent.

#### *3.11.7.8.2 Alteration of outflows and reservoir levels*

The following measures would affect recreational value and reservoir levels. Reducing minimum flows to Congressionally authorized minimum flow requirements in particular would benefit water-based recreation and water supply for irrigation and M&I purposes.

- Fall Creek drawdown;
- Augment instream flows by using the inactive pool (#718) (CTG, DOR, FCR, BLU);

- Augment instream flows by using the power pool (#304) (LOP, HCR, CGR, GPR, DET); and
- Reduce minimum flows to Congressionally authorized minimum flow requirements (#723) (All reservoirs).

**Recreational Value**

Under Alternative 1, the reduction of flows to Congressionally authorized minimum flow requirements (#723) would increase reservoir levels; and increase both the quality of recreational opportunities offered at reservoirs and the ability of reservoirs to support increased numbers of visitors over the life of the project. These visitors would in turn generate indirect beneficial socioeconomic effects through the expenditure of funds in support of their activity of choice. As a result of increased recreational opportunity and quality, average annual NED recreational benefits are expected to increase under Alternative 1 throughout the WVS. These recreational benefits would result in the indirect support of 11.3 jobs to meet increased recreational demand and add $723,000 to the economy of the ROI. These indirect benefits would be minor in magnitude, long term in duration and regional in extent.

**Irrigation and M&I Use**

Under Alternative 1, peak conservation storage would increase 168,000 acre-feet and benefit water users throughout the WVS. Increased availability of irrigation water would allow for increases in the amount of irrigated acreage throughout the ROI and reduced prevalence of crop damages for the life of the project, stimulating indirect and induced socioeconomic benefits throughout the ROI as crops are brought to market. M&I users would also likely be able to use the majority of their water allocations, decreasing costs of living and business throughout the ROI. As such, the increased water supply as a result of the alteration of outflows and reservoir levels would have beneficial effects that are minor in magnitude, regional in extent, and long-term.

As discussed in Section 3.11.2.4.2 and under the NAA, the one drawdown during the fall at one location (Fall Creek) would have negligible, regional, short- and long-term recurring effects to water supply.

**Quality of Life**

As discussed above in Section 3.11.2.4.2 and the No Action Alternative, the Fall Creek Drawdown would continue to adversely affect the quality of life for nearby residents at Fall Creek. However, there are no cities directly on the shores of the Fall Creek Reservoir therefore effects to the quality of life would be minor and localized. Effects would occur in the short term and recur annually in the long term.

**Non-Use and Existence Values**

As discussed above in Section 3.11.2.4.3, implementation of the measures under Alternative 1 would preserve the existence value of the UWR Chinook salmon and UWR steelhead and therefore have long-term, minor beneficial effects to society.

*3.11.7.8.3 Climate change*

As discussed in Section 3.11.2.5.4, climate change would adversely affect socioeconomic resources due to wetter winters (where more precipitation falls as rain rather than snow), less snowpack, drier summers, increased air and water temperatures, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB. These factors would contribute to indirect adverse effects to socioeconomic resources throughout the entirety of the ROI through decreased recreational revenues resulting from lower recreational quality and visitation as well as increased costs to irrigation and M&I.

Under Alternative 1, construction measures would cause adverse effects to population and housing with an in-migration of workers to the ROI. Increased capital expenditures would benefit labor and earnings and low-income populations. Climate change would not exacerbate these effects and the magnitude, extent, and duration would remain the same. Effects to the recreational value and viewshed (and therefore quality of life) from construction activities and the Fall Creek Drawdown could be exacerbated if wildfires and HABs further affect turbidity and water quality. However, effects from construction activities and the Fall Creek drawdown in combination with climate change would likely remain moderate, localized, and occur in the short, medium, and long term (recurring).

Under Alternative 1, beneficial effects resulting from increased reservoir storage would be minor, regional, and long term. These beneficial effects would offset the adverse effects from climate change on recreational value and water supply described above. As such, the alteration of outflows and reservoir levels in combination with climate change would have long term, regional, negligible to minor, beneficial effects.

### *3.11.7.9 Alternative 2A – Integrated Water Management and ESA-Listed Fish Alternative*

Construction and design expenditures associated with Alternative 2A would total only approximately $1.3B, which is just over half of those which would occur under Alternative 1. Fewer construction and infrastructure improvement activities would be implemented compared to Alternative 1 and would impact fewer project locations. As a result, the magnitude of beneficial socioeconomic impacts to labor and earnings and low-income populations, the adverse effects to recreational value and quality of life due to construction-related emissions, noise generation, and traffic would be less severe compared to Alternative 1.

Beneficial socioeconomic effects to labor and earnings and low-income populations due to construction and maintenance of structural measures would be negligible to minor in magnitude, and regional in extent in the short term, with construction-induced economic activity benefits increasing in the medium term while construction activities are taking place. Adverse effects to population and housing would be negligible to minor, regional in extent, and short and medium term in duration. Adverse effects to quality of life and recreational value from construction would be minor in magnitude, regional in extent, and occur in the short and medium term. Long-term visual effects to quality of life from the erection of new structures would be negligible to minor. Beneficial, indirect effects to recreation expenditures from the alteration of outflows and reservoir storage measures under Alternative 2A would be negligible in magnitude, regional in extent, and long-term. Indirect, adverse effects to M&I and agricultural water supply costs from the alteration of outflows and reservoir storage measures under Alternative 2A would be minor in magnitude, regional in extent, and long-term. Preserving the existence value of the UWR Chinook salmon and UWR steelhead would have long-term, minor beneficial effects to society in the state and beyond. Alternative 2A would have similar effects to socioeconomic resources as Alternatives 2B and would have effects of substantially lower magnitude than Alternatives 1, 3A, 3B and 4.

###### *3.11.7.9.1 Construction, Operation, Management, Rehabilitation, and Replacement of Structural Measures*

The following measures would increase construction expenditures within the ROI for the duration of the construction phase, resulting in beneficial and adverse socioeconomic effects through the mechanisms discussed in Section 3.11.4.2.1.

- Gravel augmentation below dams (#384) (CGR, BLU, FOS, BCL);
- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) (All reservoirs);
- Maintenance of existing and new fish release sites above dams (#726) (LOP, FCR, HCR, CGR, DET, BCL, GPR, FOS);
- Foster Fish Ladder Temperature Improvement (#479) (FOS);
- Construction of WTC towers (#105) (DET);
- Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) (GPR);
- Use of spillway for surface spill in the summer (#721) (GPR);
- Construction of AFFs (#722) (GPR);
- Provide Pacific lamprey passage and infrastructure (#52) (GPR);
- Construction of structural downstream fish passage (#392) (LOP, CGR, FOS, DET); and
- Operation, Maintenance, Repair, Replacement, and Rehabilitation.

**Labor and Earnings**

The socioeconomic effects of construction and design expenditures under Alternative 2A would be similar to those experienced under Alternative 1, but of substantially smaller magnitude. Construction and design expenditures associated with Alternative 2A would total only approximately $1.3B, which is almost half of those which would occur under Alternative 1. Hence, while construction-related expenditures would generate beneficial effects through the mechanisms discussed in Section 3.11.2.4.1, the magnitude of socioeconomic effects would be smaller than those experienced under Alternative 1; direct, indirect, and induced benefits would result from the hiring of labor, purchase of materials, and increased revenues at retail and food service establishments throughout the ROI. Most of these economic activity benefits would be limited to the medium-term duration of individual construction projects included under Alternative 2A, and be regional in extent.

**Table 3.11-11. Effects of Construction Spending Under Alternative 2A**

| Area | Local Capture | Output | Jobs* | Labor Income | Value Added |
|---|---|---|---|---|---|
| **Local** | | | | | |
| Direct Impact | | $1,046,004,077 | 11791.7 | $857,908,409 | $500,734,490 |
| Secondary Impact | | $968,997,926 | 5966.7 | $320,828,677 | $549,682,271 |
| Total Impact | $1,046,004,077 | $2,015,002,002 | 17758.4 | $1,178,737,086 | $1,050,416,762 |
| **State** | | | | | |
| Direct Impact | | $1,083,446,694 | 12401.1 | $903,804,196 | $559,127,504 |
| Secondary Impact | | $1,322,009,115 | 7361.3 | $448,336,474 | $753,163,709 |
| Total Impact | $1,083,446,694 | $2,405,455,808 | 19762.3 | $1,352,140,670 | $1,312,291,212 |
| **US** | | | | | |
| Direct Impact | | $1,083,639,981 | 12488.2 | $917,658,223 | $572,379,979 |
| Secondary Impact | | $2,498,497,903 | 11605.2 | $776,080,790 | $1,342,681,027 |
| Total Impact | $1,083,639,981 | $3,582,137,884 | 24093.5 | $1,693,739,014 | $1,915,061,005 |

* Jobs are presented in full-time equivalence (FTE)

The estimated overall regional economic development impacts for Alternative 2A shown in Table 3.11-11 are explained by project in the following four paragraphs.

**Foster and Green Peter** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Foster and Green Peter are estimated to be $80,247,000. Of this total expenditure, $77,459,579 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $80,247,000 support a total of 1,278.9 full-time equivalent jobs, $79,505,939 in labor income, $65,171,785 in the gross regional product, and $136,622,697 in economic output in the local impact area. More broadly, these expenditures support 1,807.7 full-time equivalent jobs, $125,705,262 in labor income, $141,552,710 in the gross regional product, and $268,720,522 in economic output in the nation.

**Detroit and Big Cliff** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Detroit and Big Cliff are estimated to be $703,350,000. Of this total expenditure, $678,553,929 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $703,350,000 support a total of 11,456.3 full-time equivalent jobs, $774,376,405 in labor income, $665,233,887 in the gross regional product, and $1,312,140,001 in economic output in the local impact area. More broadly, these expenditures support 15,457.7 full-time equivalent jobs, $1,106,370,617 in labor income, $1,240,683,124 in the gross regional product, and $2,355,285,298 in economic output in the nation.

**Cougar and Blue River** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Cougar and Blue River are estimated to be $174,700,000. Of this total expenditure, $168,758,669 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $174,700,000 support a total of 2,923.2 full-time equivalent jobs, $189,047,713 in labor income, $186,228,972 in the gross regional product, and $329,520,341 in economic output in the local impact area. More broadly, these expenditures support 3,973.6 full-time equivalent jobs, $268,662,724 in labor income, $310,075,141 in the gross regional product, and $557,580,518 in economic output in the nation.

**Hills Creek, Lookout Point, Dexter, Fall Creek** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Hills Creek, Lookout Point, Dexter, and Fall Creek are estimated to be $125,500,000. Of this total expenditure, $121,231,900 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $125,500,000 support a total of 2,100.0 full-time equivalent jobs, $135,807,029 in labor income, $133,782,118 in the gross regional product, and $236,718,963 in economic output in the local impact area. More broadly, these expenditures support 2,854.5 full-time equivalent jobs,

$193,000,411 in labor income, $222,750,030 in the gross regional product, and $400,551,546 in economic output in the nation.

**Population and Housing**

As discussed above in Section 3.11.2.4.1, given the current availability of approximately 21,100 housing units within the ROI (USCB 2019c), any small in-migration resulting from construction activities under Alternative 2A could be measurable and could be noticeable but would not affect housing availability or pricing for current residents. Any adverse effects which may occur would only persist for the short- or medium-term duration of the construction period depending on the scale of a given project. Approximately $1.3B in construction and design expenditures under Alternative 2A would have negligible to minor, regional, adverse effects to population and housing.

**Quality of Life and Recreational Value**

As with Alternative 1, construction-related activities could potentially reduce the quality of life of residents and recreational value in the vicinity of project sites through increased noise, emission, and traffic levels. Work-related activities involving heavy equipment would cause visual and auditory disturbance to local residents and recreational users in the vicinity of the project areas, as well as reduce air quality from project-related emissions. Traffic levels would similarly increase during work periods but would be confined to the immediate vicinity of work sites and would not substantially reduce resident access to community resources or visitor access to reservoirs. These effects would be most pronounced within the towns of Detroit and Sweet Home, in particular due to the construction of a WTC tower at Detroit and construction of structural downstream fish passages at Detroit and Foster; both of which are relatively larger projects that would occur in the medium-term. Construction-related activities would have local, major effects in the short and medium term. Long-term visual effects to quality of life from the erection of new structures would be negligible to minor.

Although these works of improvement have been specifically designed to meet the requirements of ESA-listed species, their populations would not return to a level that would directly affect recreational fishing. However, other species including those within recreational fisheries would also benefit from improved habitat value. Recreational fishing use and visitation within the ROI would likely increase in the long term and have negligible, beneficial, indirect effects on the recreational value of affected reservoirs.

**Low-Income Populations**

As discussed above in Section 3.11.2.4.1, if low-income populations in Lane, Linn, and Marion counties are hired to work on these projects, they could experience negligible to minor health benefits through economic pathways in the short and medium term. There may also be negligible to minor adverse effects to the physical health and well-being of low-income communities (from increased air emissions and noise levels) that are hired to work at the sites for the duration of these projects. Once construction is complete, workers would not be on-site and therefore there would be no long-term health effects. Benefits would only persist for the duration of the construction and infrastructure improvement phases with only a small number of permanent maintenance jobs created; therefore, long-term beneficial effects would be negligible. All effects would be regional in extent.

#### *3.11.7.9.2 Alteration of outflows and reservoir levels*

The following measures would affect recreational value and reservoir levels.

- Fall Creek Drawdown;
- Foster Fish Ladder Temperature Improvement (#479);
- Use of regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) (GPR);
- Use of spillway for surface spill in summer (#721) (GPR);
- Augmentation of instream flows by using the inactive pool (#718) (FCR, BLU);
- Augmentations of instream flows by using the power pool (#304) (LOP, HCR, CGR, GPR, DET);
- Integrated temperature and habitat flow regime (#30a) (All reservoirs);
- Deeper fall reservoir drawdowns for fish passage (#40) (GPR);
- Pass water over spillway in spring for fish passage (#714) (GPR).

**Recreational Value**

Deep fall reservoir drawdowns at Green Peter would likely decrease visitation in the short term but would not likely affect revenues due to seasonally low levels of visitation during this timeframe. Hence, these short- and long-term recurring adverse effects would be negligible and localized.

Alteration of outflows and reservoir levels under Alternative 2A would likely improve the recreational quality of the ROI and increase recreational revenues within the ROI for the duration of the project life. Alternative 2A would generate similar negligible, long-term increases in recreational revenues as Alternative 1 from increased habitat values of recreational fisheries resulting from the increase of cool water outflows throughout the WRB system. As a result of increased recreational opportunity and quality, average annual NED recreational benefits are expected to increase under Alternative 2A.2A. These recreational benefits would result in the indirect and support of 7.5 jobs to meet increased recreational demand and add $509,000 of total value to the economy of the ROI. These beneficial effects to socioeconomic resources would be negligible in magnitude, regional, and long-term.

**Irrigation and M&I Use**

Alteration of outflows under Alternative 2A would minorly reduce the availability of water supply for M&I and agricultural users. Peak conservation storage would decrease by 64,000 acre-feet from the NAA. Decreased availability of irrigation water would cause commensurate decreases in the amount of irrigated acreage throughout the ROI and increased prevalence of crop damages for the life of the project, stimulating indirect and induced adverse socioeconomic effects throughout the ROI. M&I users would also need to purchase small amounts of supplemental water from other sources, increasing costs of living and business throughout the ROI. Hence, indirect effects to socioeconomic resources from reduced water availability would be minor in magnitude, regional, and long-term.

**Quality of Life**

As discussed above in Section 3.11.2.4.2, drawdowns under would continue to adversely affect the quality of life for nearby residents at Fall Creek. Additionally, under this alternative, deep fall reservoirs drawdowns at Green Peter would similarly affect the quality of life for nearby residents at Green Peter. There are no cities directly on the shores of Fall Creek or Green Peter and therefore effects to the quality of life would be minor and localized. Effects would occur in the short term and recur annually in the long term.

**Non-Use and Existence Values**

As discussed above in Section 3.11.2.4.3, implementation of the measures under Alternative 2A would preserve the existence value of the UWR Chinook salmon and UWR steelhead and therefore have long-term, minor beneficial effects to society.

#### *3.11.7.9.3 Suite of Near-Term Operations*

Near-term operations that could affect socioeconomic resources include deep drawdowns, extended deep drawdowns, RO prioritization, and delayed reservoir refills for improved downstream fish passage. Visitation would likely further decrease due to decreased recreational quality of reservoirs and could affect recreational revenues. Costs to agricultural and M&I users would further increase due to reduced WVS water availability; and the loss of surface water would adversely affect the viewshed for nearby residents for longer than three weeks. As such, the resulting effects to socioeconomic resources as they relate to agricultural irrigation and M&I water use, quality of life, and recreational value of reservoirs would range from minor to moderate and adverse in the short term and long term (recurring).

The suite of near-term operations would also further augment fish spawning and rearing habitat, improve instream water quality by ensuring instream temperature and TDG control, ensure adequate streamflow for biologically justified flows, and improve fish passage. As such, the implementation of these near-term operations would have indirect, minor beneficial effects to the recreational value in the long term.

#### *3.11.7.9.4 Climate change*

As discussed in Section 3.11.2.3.1, climate change is expected to result in wetter winters (where more precipitation falls as rain rather than snow), less snowpack, drier summers, increased air and water temperatures, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB, independent of the O&M of the WVS over the next 30 years. These factors in combination with decreased reservoir storage under Alternative 2A would contribute to indirect adverse effects to socioeconomic resources throughout the entire ROI through decreased recreational revenues resulting from lower recreational quality and visitation as well as increased costs to irrigation and M&I. These adverse effects would be additive, long term, and minor to moderate.

Under Alternative 2A, effects to visitation and the viewshed (and therefore quality of life) from construction activities and the Fall Creek and Green Peter drawdowns could be exacerbated if wildfires and HABs further affect turbidity and water quality. However, effects from construction activities and drawdowns in combination with climate change would likely remain minor, localized, and occur in the short, medium, and long term (recurring).

### *3.11.7.10 Alternative 2B – Integrated Water Management and ESA-Listed Fish Alternative (using diversion tunnel at CGR)*

Alternative 2B2B is functionally similar to Alternative 2A and is $42M lower in construction and design expenditures than Alternative 2A. It differs primarily in the omission of augmentation of instream flows by using the power pool (#304) at Cougar Reservoir, omission of the construction of structural downstream fish passages (#392) at Cougar Reservoir, inclusion of deeper fall reservoir drawdowns for fish passage (#40) at Cougar Reservoir, and the inclusion of spring reservoir drawdowns for downstream fish passage (#720) at Cougar Reservoir.

Under Alternative 2B, beneficial socioeconomic effects to labor and earnings and low-income populations due to construction and maintenance of structural measures would be negligible to minor in magnitude, regional in extent in the short-term and major in the medium-term while construction is taking place. Adverse effects to population and housing would be negligible to minor, regional in extent, and short and medium term in duration. Adverse effects to quality of life and recreational value from construction would be minor in magnitude, regional in extent, and occur in the short and medium term. Long-term visual effects to quality of life from the erection of new structures would be negligible to minor. Beneficial, indirect effects to recreation expenditures from the alteration of outflows and reservoir storage measures under Alternative 2B would be negligible in magnitude, regional in extent, and long-term. Indirect, adverse effects to M&I and agricultural water supply costs from the alteration of outflows and reservoir storage measures under Alternative 2B would be minor in magnitude, regional in extent, and long-term. Preserving the existence value of the UWR Chinook salmon and UWR steelhead would have long-term, minor beneficial effects to society in the state and beyond. Alternative 2B would have similar effects to socioeconomic resources as Alternatives 2A and would have effects of substantially lower magnitude than Alternatives 1, 3A, 3B and 4.

#### *3.11.7.10.1 Construction, Operation, Management, Rehabilitation, and Replacement of Structural Measures*

The same measures as those under Alternative 2A would occur under Alternative 2B, resulting in beneficial and adverse socioeconomic effects through the mechanisms discussed in Section 3.11.4.2.1.

- Gravel augmentation below dams (#384) (CGR, BLU, FOS, BCL);
- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) (All reservoirs);
- Maintenance of existing and new fish release sites above dams (#726) (LOP, FCR, HCR, CGR, FOS, GPR, BCL, DET);
- Foster Fish Ladder Temperature Improvement (#479) (FOS);
- Construction of WTC towers (#105) (DET);
- Use of regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) (GPR);
- Use of spillway for surface spill in summer (#721) (GPR);
- Construction of AFFs (#722) (GPR);
- Provide Pacific lamprey passage and infrastructure (#52) (GPR);
- Construction of structural downstream fish passage (#392) (LOP, FOS, DET); and
- Operation, Maintenance, Repair, Replacement, and Rehabilitation. (All reservoirs)

**Labor and Earnings**

Given their functional similarity, the socioeconomic effects of Alternatives 2A and 2B are very similar and are affected by the same mechanisms discussed in Section 3.11.2.4; the primary differences result from $42M lower construction and design expenditures of Alternative 2B. Although these costs are lower than those of Alternative 2A, it is not likely that this reduction would substantially alter the support of jobs, in-migration of populations, or noticeably decrease consumer demand within the ROI from those that would occur under Alternative 2A. As such, beneficial socioeconomic effects due to increased construction expenditures under Alternative 2B would be negligible to minor in magnitude, in the short-term, with economic activity benefits increasing while construction is occurring in the medium-term, and regional in extent.

**Table 3.11-12. Effects of Construction Spending Under Alternative 2B**

| Area | Local Capture | Output | Jobs* | Labor Income | Value Added |
|---|---|---|---|---|---|
| **Local** | | | | | |
| Direct Impact | | $997,969,892 | 12385.5 | $830,633,199 | $543,452,004 |
| Secondary Impact | | $885,571,664 | 5406.8 | $291,828,981 | $503,333,550 |
| Total Impact | $997,969,892 | $1,883,541,557 | 17792.3 | $1,122,462,180 | $1,046,785,555 |
| **State** | | | | | |
| Direct Impact | | $1,033,795,181 | 12933.3 | $873,509,300 | $596,658,309 |
| Secondary Impact | | $1,204,458,756 | 6668.3 | $407,333,294 | $688,004,550 |
| Total Impact | $1,033,795,181 | $2,238,253,937 | 19601.6 | $1,280,842,594 | $1,284,662,859 |
| **US** | | | | | |
| Direct Impact | | $1,034,284,258 | 13023.2 | $886,947,021 | $607,810,246 |
| Secondary Impact | | $2,268,421,224 | 10489.2 | $704,340,219 | $1,221,735,739 |
| Total Impact | $1,034,284,258 | $3,302,705,482 | 23512.3 | $1,591,287,241 | $1,829,545,985 |

* Jobs are presented in full-time equivalence (FTE)

The estimated overall regional economic development impacts for Alternative 2B shown in Table 3.11-12 are explained by project in the following four paragraphs.

**Foster and Green Peter** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Foster and Green Peter are estimated to be $80,247,000. Of this total expenditure, $77,345,223 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $80,247,000 support a total of 1,347.5 full-time equivalent jobs, $80,035,207 in labor income, $71,250,544 in the gross regional product, and $133,543,743 in economic output in the local impact area. More broadly, these expenditures support 1,849.1 full-time equivalent jobs, $123,045,012 in labor income, $141,701,726 in the gross regional product, and $256,119,999 in economic output in the nation.

**Detroit and Big Cliff** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Detroit and Big Cliff are estimated to be $703,350,000. Of this total expenditure, $677,967,671 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $703,350,000 support a total of 12,241.5 full-time equivalent jobs, $770,596,489 in labor income, $707,757,577 in the gross regional product, and $1,276,182,647 in economic output in the local impact area. More broadly, these expenditures support 15,949.6 full-time equivalent jobs, $1,081,933,836 in labor income, $1,241,989,219 in the gross regional product, and $2,244,844,062 in economic output in the nation.

**Cougar and Blue River** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Cougar and Blue River are estimated to be $125,700,000. Of this total expenditure, $121,425,098 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $125,700,000 support a total of 2,103.3 full-time equivalent jobs, $136,023,455 in labor income, $133,995,316 in the gross regional product, and $237,096,204 in economic output in the local impact area. More broadly, these expenditures support 2,859.1 full-time equivalent jobs, $193,307,982 in labor income, $223,105,010 in the gross regional product, and $401,189,875 in economic output in the nation.

**Hills Creek, Lookout Point, Dexter, Fall Creek** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Hills Creek, Lookout Point, Dexter, and Fall Creek are estimated to be $125,500,000. Of this total expenditure, $121,231,900 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $125,500,000 support a total of 2,100.0 full-time equivalent jobs, $135,807,029 in labor income, $133,782,118 in the gross regional product, and $236,718,963 in economic output in the local impact area. More broadly, these expenditures support 2,854.5 full-time equivalent jobs, $193,000,411 in labor income, $222,750,030 in the gross regional product, and $400,551,546 in economic output in the nation.

**Population and Housing**

As discussed above in Section 3.11.2.4.1, given the current availability of approximately 21,100 housing units within the ROI (USCB 2019c), any small in-migration resulting from construction activities under Alternative 2B could be measurable and could be noticeable but would not affect housing availability or pricing for current residents. Any adverse effects which may occur would only persist for the short- or medium-term duration of the construction period depending on the scale of the project in question. As such, adverse effects on population and housing would be negligible to minor and regional in extent.

**Quality of Life and Recreational Value**

Quality of life and recreational value of reservoirs would be reduced in the vicinity of project sites during the construction phase due to visual disturbance from the presence of heavy equipment and workers, increased air emissions, noise, and traffic. Effects would be confined to the immediate vicinity of project sites (reservoirs and towns bordering reservoirs) and would only persist for the duration of construction projects. As with Alternative 2A, these effects would be most pronounced in the towns of Detroit and Sweet Home, in particular due to the construction of a WTC tower at Detroit and construction of structural downstream fish passages at Detroit and Foster; both of which are relatively larger projects that would occur in the medium-term. Effects to quality of life and recreational value due to construction-related activity under Alternative 2B would be short- and medium-term, localized, and major. Long-term visual effects to quality of life from the erection of new structures would be negligible to minor.

Although these works of improvement have been specifically designed to meet the requirements of ESA-listed species, their populations would not return to a level that would directly affect recreational fishing. However, other species including those within recreational fisheries would also benefit from improved habitat value. Recreational fishing use and visitation within the ROI would likely increase in the long term and have negligible, beneficial, indirect effects on the recreational value of affected reservoirs.

**Low Income Populations**

Low-income populations in Lane, Linn, and Marion counties that are hired to work on these projects would experience negligible to minor health benefits through economic pathways in the short and medium term. There may also be negligible to minor adverse effects to the physical health and well-being of low-income communities (from increased air emissions and noise levels) that are hired to work at the sites for the duration of these projects, but these effects would not persist beyond the duration of the construction phase. Benefits would only persist for the duration of the construction and infrastructure improvement phases with only a small number of permanent maintenance jobs created; therefore, long-term beneficial effects would be negligible. All effects would be regional in extent.

#### *3.11.7.10.2 Alteration of outflows and reservoir levels*

The following measures would affect recreational value and reservoir levels.

- Fall Creek drawdown;
- Spring reservoir drawdown for downstream fish passage (#720) (CGR);
- Foster Fish Ladder Temperature Improvement (#479) (FOS);
- Use of regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) (GPR);

- Use of spillway for surface spill in summer (#721) (GPR);
- Augmentation of instream flows by using the inactive pool (#718) (FCR, BLU);
- Augmentation of instream flows by using the power pool (#304) (LOP, HCR, GPR, DET);
- Integrated temperature and habitat flow regime (#30a) (All reservoirs);
- Deeper fall reservoir drawdowns for fish passage (#40) (CGR, GPR); and
- Pass water over the spillway in spring for fish passage (#714) (GPR).

**Recreational Value**

As with Alternative 2A, deeper fall reservoirs drawdowns (#40) at Green Peter would likely decrease visitation in the short term but would not likely affect revenues due to seasonally low levels of visitation during this timeframe. Spring reservoir drawdowns (#720) in particular at Cougar Reservoir under would Alternative 2B would reduce recreational expenditures at this reservoir throughout the life of the project compared to those under Alternative 2A due to decreased recreational quality during the spring recreation season for the life of the project. However, Cougar is one of the least visited reservoirs of the 13 reservoirs; and visitors spend the least amount of dollars per visit at this reservoir (USACE 2019g). Hence, these short- and long-term recurring adverse effects from drawdowns at Fall Creek, Green Peter, and Cougar would be negligible and localized.

Conversely, fall and spring reservoir drawdowns would negligibly increase habitat values for recreational fish species throughout the ROI for the life of the project, resulting in increased recreational visitation and expenditures. Average annual NED benefits under Alternative 2B would be slightly higher than the NAA; these benefits would support 5.2 jobs and $356,000 in total economic value. These regional, beneficial effects would ultimately be negligible in magnitude and long-term.

**M&I Use and Irrigation**

Alternative 2B would result in a decrease of 64,000 acre-feet of conservation storage from the NAA. Reduced conservation storage would increase water costs and crop damages to M&I and irrigation users throughout the ROI, resulting in general cost of living increases for the life of the project. These regional, adverse, indirect socioeconomic effects would be minor and long-term.

**Quality of Life**

As discussed above in Section 3.11.2.4.2, drawdowns under this alternative would also adversely affect the quality of life for nearby residents at Fall Creek and Green Peter. Additionally, under this alternative, deep fall and spring reservoirs drawdowns at Cougar would similarly affect the quality of life for nearby residents. There are no cities directly on the shores of Fall Creek, Green Peter, or Cougar and therefore effects to the quality of life would be minor and localized. Effects would occur in the short term and recur annually in the long term.

**Non-Use and Existence Values**

As discussed above in Section 3.11.2.4.3, implementation of the measures under Alternative 2B would preserve the existence value of the UWR Chinook salmon and UWR steelhead and therefore have long-term, minor beneficial effects to society.

*3.11.7.10.3 Suite of Near-Term Operations*

Near-term operations that could affect socioeconomic resources include deep drawdowns, extended deep drawdowns, RO prioritization, and delayed reservoir refills for improved downstream fish passage. Visitation would likely further decrease due to decreased recreational quality of reservoirs and could affect recreational revenues. Costs to agricultural and M&I users would further increase due to reduced WVS water availability; and the loss or surface water would adversely affect the viewshed for nearby residents for longer than three weeks. As such, the resulting effects to socioeconomic resources as they relate to agricultural irrigation and M&I water use, quality of life, and recreational value of reservoirs would range from minor to moderate and adverse in the short term and long term (recurring).

The suite of near-term operations would also further augment fish spawning and rearing habitat, improve instream water quality by ensuring instream temperature and TDG control, ensure adequate streamflow for biologically justified flows, and improve fish passage. As such, the implementation of these near-term operations would have indirect, minor beneficial effects to the recreational value in the long-term.

*3.11.7.10.4 Climate change*

As discussed in Section 3.11.2.3.1, climate change is expected to result in wetter winters (where more precipitation falls as rain rather than snow), less snowpack, drier summers, increased air and water temperatures, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB, independent of the O&M of the WVS over the next 30 years. These factors in combination with decreased reservoir storage under Alternative 2B2B would contribute to indirect adverse effects to socioeconomic resources throughout the entire ROI through decreased recreational revenues resulting from lower recreational quality and visitation as well as increased costs to irrigation and M&I. These adverse effects would be additive, long term, and minor to moderate.

Under Alternative 2B, effects to visitation and the viewshed (and therefore quality of life) from construction activities and the Fall Creek, Green Peter, and Cougar drawdowns could be exacerbated if wildfires and HABs further affect turbidity and water quality. However, effects from construction activities and drawdowns in combination with climate change would likely remain minor, localized, and occur in the short, medium, and long term (recurring).

### *3.11.7.11 Alternative 3A3A – Operations-Focused Fish Passage Alternative*

Alternative 3A consists primarily of alteration of outflows and reservoir storage, along with minor structural improvements and maintenance which increase stream flows and enhance fish passage in support of improved survival of ESA-listed fish species. Construction and design expenditures associated with Alternative 3A would total only approximately $470M, which is 36 percent of those of Alternatives 2A and 2B. Construction expenditures would be lowest for this alternative, and as such would result in fewer construction and infrastructure improvement activities compared to all other alternatives. As a result, the magnitude of beneficial socioeconomic impacts to labor and earnings and low-income populations, the adverse effects to recreational value and quality of life due to construction-related emissions, noise generation, and traffic would be less severe compared to all other alternatives. However, adverse effects to recreational value, agricultural irrigation and M&I use, and quality of life from the 10 drawdowns at seven reservoirs would be more severe under this alternative (and Alternative 3B) compared to Alternatives 1, 2A, 2B, 4, and 5.

Under Alternative 3A, beneficial socioeconomic effects to labor and earnings and low-income populations due to construction of structural measures would be negligible in magnitude, regional in extent, and occur in the short and medium term, with construction spending induced economic activity benefits increasing in the medium-term while construction is taking place. Adverse effects to population and housing, quality of life, and recreational value from construction would be negligible in magnitude, regional in extent, and occur in the short and medium term. Long-term visual effects to quality of life from the erection of new structures would be negligible. Adverse effects to recreation expenditures from the alteration of outflows and reservoir storage and levels under Alternative 3A would be major in magnitude, regional in extent, and long-term. Adverse effects to M&I and agricultural water supply costs from the alteration of outflows and reservoir storage and levels under Alternative 3A would be major in magnitude, regional in extent, and long-term. Preserving the existence value of the UWR Chinook salmon and UWR steelhead would have long-term, minor beneficial effects to society in the state and beyond. Alternative 3A would have greater adverse long-term effects to socioeconomic resources than Alternatives 2A and 2B (but lesser beneficial and adverse short- and medium-term effects), nearly identical effects as Alternative 3B and would have effects of substantially lower magnitude in the short- and medium-term (and more adverse long-term effects) than Alternatives 1 and 4.

#### *3.11.7.11.1 Construction, Operation, Management, Rehabilitation, and Replacement of Structural Measures*

The following measures would increase construction expenditures within the ROI for the duration of the construction phase, resulting in beneficial and adverse socioeconomic effects through the mechanisms discussed in Section 3.11.4.2.1.

- Gravel augmentation below dams (#384) (CGR, BLU, FOS, BCL);

- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) (All reservoirs);
- Maintenance of existing and new fish release sites above dams (#726) (LOP, FCR, HCR, CGR, FOS, GPR, BCL, DET);
- Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) (LOP, GPR, DET);
- Use of spillway for surface spill in summer (#721) (LOP, HCR, BLU, FOS, GPR, DET);
- Construction of AFFs (#722) (HCR, BLU, GPR);
- Provide Pacific lamprey passage and infrastructure (#52) (HCR, BLU, GPR); and
- Operation, Maintenance, Repair, Replacement, and Rehabilitation (All Reservoirs)

**Labor and Earnings**

Socioeconomic effects due to construction expenditures under Alternative 3A would be similar to those experienced under Alternatives 2A and 2B, but of smaller magnitude. Construction and design expenditures associated with Alternative 3A would total only approximately $470M, which is 36 percent of those of Alternatives 2A and 2B. Hence, while these expenditures would generate beneficial effects through the mechanisms discussed in Section 3.11.2.4.1, the magnitude of socioeconomic effects would be smaller than those experienced under Alternatives 1, 2A, and 2B; direct, indirect, and induced effects would result from the hiring of labor, purchase of materials from vendors, and increased revenues at retail and food service establishments. These beneficial effects would occur in the short and medium term and be regional in extent.

**Table 3.11-13. Effects of Construction Spending Under Alternative 3A**

| Area | Local Capture | Output | Jobs* | Labor Income | Value Added |
|---|---|---|---|---|---|
| **Local** | | | | | |
| Direct Impact | | $319,763,958 | 3708.4 | $254,987,819 | $175,165,073 |
| Secondary Impact | | $297,429,584 | 1834.7 | $100,560,713 | $171,904,667 |
| Total Impact | $319,763,958 | $617,193,543 | 5543.0 | $355,548,532 | $347,069,740 |
| **State** | | | | | |
| Direct Impact | | $330,749,544 | 4093.1 | $278,857,768 | $193,022,266 |
| Secondary Impact | | $385,378,194 | 2138.1 | $130,323,386 | $220,121,625 |
| Total Impact | $330,749,544 | $716,127,739 | 6231.2 | $409,181,155 | $413,143,892 |
| **US** | | | | | |
| Direct Impact | | $330,932,941 | 4184.0 | $283,668,494 | $196,445,931 |
| Secondary Impact | | $725,811,403 | 3356.5 | $225,362,978 | $390,910,524 |
| Total Impact | $330,932,941 | $1,056,744,344 | 7540.5 | $509,031,470 | $587,356,457 |

* Jobs are presented in full-time equivalence (FTE)

The estimated overall regional economic development impacts for Alternative 3A shown in Table 3.11-13 are explained by project in the following four paragraphs.

**Foster and Green Peter** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Foster and Green Peter are estimated to be $32,547,000. Of this total expenditure, $31,370,082 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $32,547,000 support a total of 546.5 full-time equivalent jobs, $32,461,100 in labor income, $28,898,170 in the gross regional product, and $54,163,373 in economic output in the local impact area. More broadly, these expenditures support 750.0 full-time equivalent jobs, $49,905,243 in labor income, $57,472,131 in the gross regional product, and $103,878,495 in economic output in the nation.

**Detroit and Big Cliff** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Detroit and Big Cliff are estimated to be $1,350,000. Of this total expenditure, $1,301,282 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $1,350,000 support a total of 23.5 full-time equivalent jobs, $1,479,072 in labor income, $1,358,460 in the gross regional product, and $2,449,487 in economic output in the local impact area. More broadly, these expenditures support 30.6 full-time equivalent jobs, $2,076,648 in labor income, $2,383,856 in the gross regional product, and $4,308,722 in economic output in the nation.

**Cougar and Blue River**- The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Cougar and Blue River are estimated to be $165,700,000. Of this total expenditure, $160,064,747 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $165,700,000 support a total of 2,772.6 full-time equivalent jobs, $179,308,564 in labor income, $176,635,035 in the gross regional product, and $312,544,479 in economic output in the local impact area. More broadly, these expenditures support 3,768.9 full-time equivalent jobs, $254,822,057 in labor income, $294,101,036 in the gross regional product, and $528,855,706 in economic output in the nation.

**Hills Creek, Lookout Point, Dexter, Fall Creek** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Hills Creek, Lookout Point, Dexter, and Fall Creek are estimated to be $131,500,000. Of this total expenditure, $127,027,847 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $131,500,000 support a total of 2,200.4 full-time equivalent jobs, $142,299,796 in labor income, $140,178,075 in the gross regional product, and $248,036,204 in economic output in the local impact area. More broadly, these expenditures support 2,991.0 full-time equivalent jobs, $202,227,522 in labor income, $233,399,434 in the gross regional product, and $419,701,421 in economic output in the nation.

**Population and Housing**

No measurable in-migration of populations would be expected under Alternative 3A. As such, Alternative 3A would have negligible, regional, short- and medium-term, adverse effects to population and housing.

**Quality of Life and Recreational Value**

While construction-related noise, emissions, and congestion could potentially reduce resident quality of life and recreational expenditures during work phases, no measurable short, medium- or long-term quality of life effects are expected under Alternative 3A given the limited number of structural measures. As with Alternatives 1, 2A, and 2B, work-related activities could potentially reduce the quality of life of residents and recreational quality in the vicinity of project sites (reservoirs and towns bordering reservoirs) through increased noise, emission, and traffic levels during the construction phase. However, none of the limited number of works of improvement proposed under Alternative 3A would occur at reservoirs with towns bordering reservoirs, except for a structural modification to the RO at Detroit to be used for temperature management. As such, adverse, short- and medium-term effects to recreational value and quality of life would be negligible in magnitude and localized. Long-term visual effects to quality of life from the erection of new structures would be negligible.

Although these works of improvement have been specifically designed to meet the requirements of ESA-listed species, their populations would not return to a level that would directly affect recreational fishing. However, other species including those within recreational fisheries would also benefit from improved habitat value. Recreational fishing use and visitation within the ROI would likely increase in the long term and have negligible, beneficial, indirect effects on the recreational value of affected reservoirs.

**Low-Income Populations**

Low-income populations in Lane, Linn, and Marion counties that are hired to work on these projects would experience negligible health benefits through economic pathways in the short and medium term. There may also be negligible adverse effects to the physical health and well-being of low-income communities (from increased air emissions and noise levels) that are hired to work at the sites for the duration of these projects, but these effects would not persist beyond the duration of the construction phase. Benefits would only persist for the duration of the construction and infrastructure improvement phases with only a small number of permanent maintenance jobs created; therefore, long-term beneficial effects would be negligible. All effects would be regional in extent.

*3.11.7.11.2 Alteration of outflows and reservoir levels*

The following measures would affect recreational value and reservoir levels.

- Fall Creek drawdown;
- Use of regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) (LOP, GPR, DET);
- Use of spillway for surface spill in summer (#721) (LOP, HCR, BLU, FOS, GPR, DET);
- Augmentation of instream flows by using the inactive pool (#718) (CTG, DOR, FCR, BLU);
- Augmentation of instream flows by using the power pool (#304) (LOP, HCR, CGR, GPR, DET);
- Integrated temperature and habitat flow regime (30a) (All reservoirs);
- Deeper fall reservoir drawdowns for fish passage (#40) (LOP, HCR, CGR, BLU, GPR, DET);
- Spring reservoir drawdown for downstream fish passage (#720) (LOP, CGR, DET); and
- Pass water over spillway in spring for fish passage (#714) (DEX, FCR, HCR, GPR, BCL).

**Recreational Value**

Alteration of outflows and reservoir level would likely substantially decrease the recreational expenditures within the ROI and while also significantly reducing the availability of water supply for M&I and agricultural users. Annual deep spring drawdowns at Cougar, Detroit, and Lookout Point reservoirs would substantially reduce their recreational value during the spring/summer recreation season. Deep fall reservoir drawdowns at Lookout Point, Hills Creek, Cougar, Blue River, Green Peter, and Detroit would similarly result in reduced recreational values for fall and winter months, but would not likely affect revenues as substantially due to seasonally low levels of visitation during this timeframe. As a result of reduced recreational opportunity and quality, average annual NED recreational benefits are expected to decrease from the NAA. These reductions would result in the loss of support for 25 jobs due to decreased recreational demand and remove $1.5M of total value to the economy of the ROI over the life of the project. These adverse, long-term, regional effects would be major in magnitude.

**M&I Use and Irrigation**

Similarly, under Alternative 3A peak conservation storage would decrease by 64 percent, a total decrease of 750,910 acre-feet from the NAA. This decrease would induce major adverse effects to water users throughout the WVS; essentially no water would be allocated for M&I and irrigation uses for the life of the project. Decreased availability of irrigation water would cause decreases in the amount of irrigated acreage throughout the ROI and increased prevalence of crop damages for the life of the project, stimulating indirect and induced adverse socioeconomic effects throughout the ROI. It is important to note that only 15 percent of agricultural producers in the WRB are reliant on WVS irrigation water supply, which limits the magnitude of potential direct, indirect, and induced impacts. Therefore, overall adverse water supply impacts to agricultural production in the WRB would only be moderate in magnitude whereas impacts to those producers reliant on WVS water would be major in magnitude. M&I users would also need to purchase large amounts of supplemental water from other sources, substantially increasing costs of living and business throughout the ROI. As such, the overall long-term, regional, adverse effects due to reduced water supply would be moderate to major in magnitude.

**Quality of Life**

Under this alternative, deep fall and spring reservoirs drawdowns at seven reservoirs would affect the quality of life for nearby residents. The city of Detroit is located directly on the shores of Detroit Reservoir, and therefore effects to the quality of life would be major and localized in the short-term and recur annually over the long term in both the fall and spring.

**Non-Use and Existence Value**

As discussed above in Section 3.11.2.4.3, implementation of the measures under Alternative 3A would preserve the existence value of the UWR Chinook salmon and UWR steelhead and therefore have long-term, minor beneficial effects to society.

*3.11.7.11.3 Suite of Near-Term Operations*

Near-term operations that could affect socioeconomic resources include deep drawdowns, extended deep drawdowns, RO prioritization, and delayed reservoir refills for improved downstream fish passage. For reasons similar to those discussed above as they relate to recreational value; agricultural irrigation and M&I use; and quality of life, effects to socioeconomic resources would be major and adverse in the short term and long term (recurring). Recreational revenues and visitation would likely further decrease due to decreased recreational quality of reservoirs; costs to agricultural and M&I users would further increase due to reduced WVS water availability; and the loss or surface water would adversely affect the viewshed for nearby residents for longer than three weeks.

The suite of near-term operations would also further augment fish spawning and rearing habitat, improve instream water quality by ensuring instream temperature and TDG control, ensure adequate streamflow for biologically justified flows, and improve fish passage. As such, the implementation of these near-term operations would have indirect, minor beneficial effects to the recreational value in the long-term.

#### *3.11.7.11.4 Climate Change*

As discussed in Section 3.11.2.3.1, climate change is expected to result in wetter winters (where more precipitation falls as rain rather than snow), less snowpack, drier summers, increased air and water temperatures, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB, independent of the O&M of the WVS over the next 30 years. These factors in combination with decreased reservoir storage and levels under Alternative 3A would contribute to indirect adverse effects to socioeconomic resources throughout the entire ROI through decreased recreational revenues resulting from lower recreational quality and visitation as well as increased costs to irrigation and M&I. These adverse effects would be additive, long term, and major.

Under Alternative 3A, effects to visitation and the viewshed (and therefore quality of life, especially at Detroit) from construction activities and the 10 total drawdowns at seven reservoirs could be exacerbated if wildfires and HABs further affect turbidity and water quality. While the magnitude of effects would still be major, effects from construction activities and drawdowns in combination with climate change would be even more severe. These effects would be regional in extent; and occur in the short, medium, and long term (recurring).

### ***3.11.7.12 Alternative B3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at COU)***

Alternative 3B is functionally similar to Alternative 3A and differs only in its omission of augmentation of instream flows by using the power pool (#304) at Cougar Reservoir, the inclusion of spring reservoir drawdowns for downstream fish passage (#720) at Green Peter and Hills Creek Reservoirs instead of at Detroit and Lookout Point Reservoirs, and the inclusion of passing water over the spillways in spring (#714) at Lookout Point instead of Dexter, Green Peter, and Hills Creek Reservoirs. Construction and design expenditures associated with Alternative 3B would total approximately $592, or $122M in additional construction and design expenditures compared to Alternative 3B.

Under Alternative 3B, beneficial socioeconomic effects to labor and earnings and low-income populations due to construction of structural measures would be negligible in magnitude, regional in extent, and occur in the short- and medium-term. Adverse effects to population and housing, quality of life, and recreational value from construction would be negligible in magnitude, regional in extent, and occur in the short- and medium-term. Adverse effects to recreation expenditures from the alteration of outflows and reservoir storage and levels under Alternative 3B would be major in magnitude, regional in extent, and long-term. Adverse effects to M&I and agricultural water supply costs from the alteration of outflows and reservoir storage and levels under Alternative 3B would be major in magnitude, regional in extent, and long-term. Preserving the existence value of the UWR Chinook salmon and UWR steelhead would have long-term, minor beneficial effects to society in the state and beyond. Alternative 3B would have greater adverse long-term effects to socioeconomic resources than Alternatives 2A and 2B (but lesser beneficial and adverse short- and medium-term effects), nearly identical effects as Alternative 3A, and would have effects of substantially lower magnitude in the short- and medium-term (and more adverse long-term effects) than Alternatives 1 and 4.

##### *3.11.7.12.1 Construction, Operation, Management, Rehabilitation, and Replacement of Structural Measures*

The following measures would marginally increase construction expenditures within the ROI for the duration of the construction phase, resulting in beneficial and adverse socioeconomic effects through the mechanisms discussed in Section 3.11.4.2.1.

- Gravel augmentation below dams (#384) (CGR, BLU, FOS, BCL);
- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) (All reservoirs);
- Maintenance of existing and new fish release sites above dams (#726) (LOP, FCR, HCR, CGR, FOS, GPR, BCL, DET);
- Use of regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) (LOP, GPR, DET);
- Use of spillway for surface spill in summer (#721) (LOP, HCR, BLU, FOS, GPR, DET);
- Construction of AFFs (#722) (HCR, BLU, GPR);
- Provide Pacific lamprey passage and infrastructure (#52) (HCR, BLU, GPR); and
- Operation, Maintenance, Repair, Replacement, and Rehabilitation (All reservoirs)

**Labor and Earnings**

Given their functional similarity, the socioeconomic effects of Alternatives 3A and 3B are very similar and are affected by the same mechanisms discussed in Section 3.11.2.8; the primary differences result from the $122M in additional construction and design expenditures of Alternative 3B3B. These costs are 26 percent greater than those of Alternative 3A. Negligible direct, indirect, and induced effects would result from the hiring of labor, purchase of materials from vendors, and increased revenues at retail and food service establishments. These beneficial effects would occur in the short and medium term, but particularly in the medium term while construction activities are occurring, and be regional in extent.

**Table 3.11-14. Effects of Construction Spending Under Alternative 3B**

| Area | Local Capture | Output | Jobs* | Labor Income | Value Added |
|---|---|---|---|---|---|
| **Local** | | | | | |
| Direct Impact | | $426,022,994 | 4925.0 | $339,638,333 | $233,661,186 |
| Secondary Impact | | $398,653,305 | 2458.6 | $134,944,248 | $230,667,781 |
| Total Impact | $426,022,994 | $824,676,299 | 7383.6 | $474,582,581 | $464,328,967 |
| **State** | | | | | |
| Direct Impact | | $440,639,319 | 5448.0 | $371,554,810 | $257,265,204 |
| Secondary Impact | | $513,417,922 | 2848.7 | $173,622,190 | $293,255,209 |
| Total Impact | $440,639,319 | $954,057,242 | 8296.7 | $545,177,000 | $550,520,414 |
| **US** | | | | | |
| Direct Impact | | $440,878,436 | 5570.8 | $377,960,100 | $261,813,218 |
| Secondary Impact | | $966,946,944 | 4471.6 | $300,235,078 | $520,782,307 |
| Total Impact | $440,878,436 | $1,407,825,380 | 10042.4 | $678,195,178 | $782,595,527 |

* Jobs are presented in full-time equivalence (FTE)

The estimated overall regional economic development impacts for Alternative 3B shown in Table 3.11-14 are explained by project in the following four paragraphs.

**Foster and Green Peter** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Foster and Green Peter are estimated to be $32,547,000. Of this total expenditure, $31,370,082 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $32,547,000 support a total of 546.5 full-time equivalent jobs, $32,461,100 in labor income, $28,898,170 in the gross regional product, and $54,163,373 in economic output in the local impact area. More broadly, these expenditures support 750.0 full-time equivalent jobs, $49,905,243 in labor income, $57,472,131 in the gross regional product, and $103,878,495 in economic output in the nation.

**Detroit and Big Cliff** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Detroit and Big Cliff are estimated to be $1,350,000. Of this total expenditure, $1,301,282 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $1,350,000 support a total of 23.5 full-time equivalent jobs, $1,479,072 in labor income, $1,358,460 in the gross regional product, and $2,449,487 in economic output in the local impact area. More broadly, these expenditures support 30.6 full-time equivalent jobs, $2,076,648 in labor income, $2,383,856 in the gross regional product, and $4,308,722 in economic output in the nation.

**Cougar and Blue River** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Cougar and Blue River are estimated to be $250,700,000. Of this total expenditure, $242,174,002 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $250,700,000 support a total of 4,194.9 full-time equivalent jobs, $271,289,420 in labor income, $267,244,437 in the gross regional product, and $472,872,063 in economic output in the local impact area. More broadly, these expenditures support 5,702.2 full-time equivalent jobs, $385,539,467 in labor income, $444,967,590 in the gross regional product, and $800,145,598 in economic output in the nation.

**Hills Creek, Lookout Point, Dexter, Fall Creek** - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Hills Creek, Lookout Point, Dexter, and Fall Creek are estimated to be $156,500,000. Of this total expenditure, $151,177,628 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $156,500,000 support a total of 2,618.7 full-time equivalent jobs, $169,352,989 in labor income, $166,827,900 in the gross regional product, and $295,191,376 in economic output in the local impact area. More broadly, these expenditures support 3,559.6 full-time equivalent jobs, $240,673,820 in labor income, $277,771,950 in the gross regional product, and $499,492,565 in economic output in the nation.

**Population and Housing**

No measurable in-migration of populations would be expected under Alternative 3B. As such, Alternative 3B would have negligible, regional, short- and medium-term, adverse effects to population and housing.

**Quality of Life and Recreational Value**

As with Alternative 3A, while construction-related noise, emissions, and congestion could potentially reduce resident quality of life and recreational expenditures during work phases, no measurable short, medium- or long-term quality of life effects are expected under Alternative 3B given the limited number of structural measures. As with Alternatives 1, 2A, and 2B, work-related activities could potentially reduce the quality of life of residents and recreational quality in the vicinity of project sites (reservoirs and towns bordering reservoirs) through increased noise, emission, and traffic levels during the construction phase. However, none of the limited number of works of improvement proposed under Alternative 3B would occur at reservoirs with towns bordering reservoirs, except for a structural modification to the RO at Detroit to be used for temperature management. As such, adverse, short- and medium-term effects to recreational value and quality of life would be negligible in magnitude and localized. Long-term visual effects to quality of life from the erection of new structures would be negligible.

Although these works of improvement have been specifically designed to meet the requirements of ESA-listed species, their populations would not return to a level that would directly affect recreational fishing. However, other species including those within recreational fisheries would also benefit from improved habitat value. Recreational fishing use and visitation within the ROI would likely increase in the long term and have negligible, beneficial, indirect effects on the recreational value of affected reservoirs.

**Low Income Populations**

Low-income populations in Lane, Linn, and Marion counties that are hired to work on these projects would experience negligible health benefits through economic pathways in the short and medium term. There may also be negligible adverse effects to the physical health and well-being of low-income communities (from increased air emissions and noise levels) that are hired to work at the sites for the duration of these projects, but these effects would not persist beyond the duration of the construction phase. Benefits would only persist for the duration of the construction and infrastructure improvement phases with only a small number of permanent maintenance jobs created; therefore, long-term beneficial effects would be negligible. All effects would be regional in extent.

#### *3.11.7.12.2 Alteration of outflows and reservoir levels*

The following measures would affect recreational value and reservoir levels.

- Fall Creek drawdown;
- Use of regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) (LOP, GPR, DET);
- Use of spillway for surface spill in summer (#721) (LOP, HCR, BLU, FOS, GPR, DET);
- Augmentation of instream flows by using the inactive pool (#718) (CTG, DOR, FCR, BLU);
- Augmentation of instream flows by using the power pool (#304) (LOP, HCR, GPR, DET);
- Integrated temperature and habitat flow regime (30a) (All reservoirs);
- Deeper fall reservoir drawdowns for fish passage (#40) (LOP, HCR, CGR, BLU, GPR, DET);
- Spring reservoir drawdown for downstream fish passage (#720) (HCR, CGR, GPR); and
- Pass water over spillway in spring for fish passage (#714) (DEX, LOP, BCL, DET).

**Recreational Value**

Spring reservoir drawdowns at Cougar, Green Peter, and Hills Creek Reservoirs under Alternative 3B3B would also substantially reduce water levels of these reservoirs throughout the life of the project, lowering the quality of their recreational experience and total visitation capacity. Deep fall reservoir drawdowns at Lookout Point, Hills Creek, Cougar, Blue River, Green Peter, and Detroit would similarly result in reduced recreational values for fall and winter months, but would not likely affect revenues as substantially due to seasonally low levels of visitation during this timeframe. Reduced recreational opportunity and quality would result in the loss of 44 jobs due to decreased recreational demand and remove $2.5M of total value to the economy of the ROI over the life of the project. These regional, long-term, adverse effects to recreational value of reservoirs would be major in magnitude.

**M&I Use and Irrigation**

Under Alternative 3B peak conservation storage would decrease by 50 percent, a total decrease of 669,000 acre-feet from the NAA. This decrease would induce major adverse effects to water users throughout the WVS throughout the life of the project; essentially no water would be allocated for M&I and irrigation uses. These users would need to purchase large amounts of supplemental water from other sources, substantially increasing costs of living and business throughout the ROI. Irrigation users who cannot source supplemental sources of water will suffer crop damages or furrow normally productive land, further exacerbating cost of living increases. Given that only 15 percent of agricultural producers are reliant on WVS water, overall adverse water supply impacts to agricultural production in the WRB would only be moderate in magnitude whereas impacts to those producers reliant on WVS water would be major in magnitude. As such, the overall long-term, regional, adverse effects of reduced water supply would be moderate to major in magnitude.

**Quality of Life**

Under this alternative, deep fall and spring reservoirs drawdowns at seven reservoirs would affect the quality of life for nearby residents. The city of Detroit is located directly on the shores of Detroit Reservoir, and therefore effects to the quality of life would be major and localized in the short-term and recur annually over the long-term in the fall.

**Non-Use and Existence Value**

As discussed above in Section 3.11.2.4.3, implementation of the measures under Alternative 3B3B would preserve the existence value of the UWR Chinook salmon and UWR steelhead and therefore have long-term, minor beneficial effects to society.

*3.11.7.12.3 Suite of Near-Term Operations*

Near-term operations that could affect socioeconomic resources include deep drawdowns, extended deep drawdowns, RO prioritization, and delayed reservoir refills for improved downstream fish passage. Recreational revenues and visitation would likely further decrease due to decreased recreational quality of reservoirs; costs to agricultural and M&I users would further increase due to reduced WVS water availability; and the loss or surface water would adversely affect the viewshed for nearby residents for longer than three weeks. As such, the resulting effects to socioeconomic resources as they relate to irrigation and M&I water use, quality of life, and recreational value of reservoirs would be major and adverse in the short term and long term (recurring).

The suite of near-term operations would also further augment fish spawning and rearing habitat, improve instream water quality by ensuring instream temperature and TDG control, ensure adequate streamflow for biologically justified flows, and improve fish passage. As such, the implementation of these near-term operations would have indirect, minor beneficial effects to the recreational value in the long-term.

*3.11.7.12.4 Climate change*

As discussed in Section 3.11.2.3.1, climate change is expected to result in wetter winters (where more precipitation falls as rain rather than snow), less snowpack, drier summers, increased air and water temperatures, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB, independent of the O&M of the WVS over the next 30 years. These factors in combination with decreased reservoir storage and levels under Alternative 3B would contribute to indirect adverse effects to socioeconomic resources throughout the entire ROI through decreased recreational revenues resulting from lower recreational quality and visitation as well as increased costs to irrigation and M&I. These adverse effects would be additive, long term, and major.

Under Alternative 3B, effects to visitation and the viewshed (and therefore quality of life, especially at Detroit) from construction activities and the 10 total drawdowns at seven reservoirs could be exacerbated if wildfires and HABs further affect turbidity and water quality. While The magnitude of effects would still be major, effects from construction activities and drawdowns in combination with climate change would be even more severe. These effects would be regional in extent; and occur in the short, medium, and long term (recurring).

***3.11.7.13 Alternative 4 – Structures-Based Fish Passage Alternative***

Alternative 4 consists almost entirely of the construction and maintenance of structural improvements which increase stream flows and enhance fish passage in support of improved survival of ESA-listed fish species. Construction and design expenditures associated with Alternative 4 would total approximately $2.6B, which is $200M greater than those of Alternative 1, and the most expensive of the alternatives.

Under Alternative 4, beneficial socioeconomic effects to labor and earnings and low-income populations due to construction of structural measures would be minor in magnitude, regional in extent, and occur in the short and medium term. These benefits would stem from large capital expenditures and increased water levels. Short- and medium-term adverse effects to population and housing would also be minor and regional. Adverse effects to quality of life and recreational value from construction would be moderate in magnitude, either localized or regional in extent, and occur in the short and medium term. Long-term visual effects to quality of life from the erection of new structures would be minor. Beneficial effects to M&I and agricultural water supply costs from the alteration of outflows and reservoir storage measures under Alternative 4 would be minor in magnitude, regional in extent, and long-term. Preserving the existence value of the UWR Chinook salmon and UWR steelhead would have long-term, minor beneficial effects to society in the state and beyond. Alternative 4 would have similar effects to socioeconomic resources as Alternative 1, and would have substantially more adverse short- and medium-term effects to labor and earnings and quality of life (and less adverse short and long-term recurring effects) than Alternatives 2A, 2B, 3A, 3B, and 5.

##### *3.11.7.13.1 Construction, Operation, Management, Rehabilitation, and Replacement of Structural Measures*

The following measures would substantially increase construction expenditures within the ROI for the duration of the construction phase, resulting in beneficial and adverse socioeconomic effects through the mechanisms discussed in Section 3.11.4.2.1.

- Gravel augmentation below dams (#384) (CGR, BLU, FOS, BCL);
- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) (All reservoirs);
- Maintenance of existing and new fish release sites above dams (#726) (LOP, FCR, HCR, CGR, FOS, GPR, BCL, DET);
- Construction of WTC towers (#105) (LOP, GCR, DET);
- Use of regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) (GPR);
- Structural improvements to reduce total dissolved gas (#174) (DEX, LOP, CGR, FOS, GPR, DET);
- Restoration of upstream and downstream passage at drop structures (#639) (FRN);
- Construction of AFFs (#722) (HCR);
- Provide Pacific lamprey passage and infrastructure (#52) (FRN, HCR);
- Construction of structural downstream fish passage (#392) (DEX, LOP, HCR, CGR, FOS, BCL, DET); and
- Operation, Maintenance, Repair, Replacement, and Rehabilitation. (All reservoirs)

**<u>Labor and Earnings</u>**

Socioeconomic effects to labor and earnings under Alternative 4 would be similar to those experienced under Alternative 1. Construction and design expenditures associated with

Alternative 4 would total approximately $2.6B, which is $200M greater than those of Alternative 1. Hence, construction-related expenditures under Alternative 4 would generate nearly identical beneficial effects as Alternative 1 through the mechanisms discussed in Section 3.11.2.3.1; minor, direct, indirect, and induced beneficial effects would result from the hiring of labor, purchase of materials from vendors, and increased revenues at retail and food service establishments. These regional, beneficial socioeconomic effects due to increased construction and maintenance expenditures under Alternative 4 would occur in the short to medium term, but will increase in the medium term while construction activities are taking place.

**Table 3.11-15. Effects of Construction Spending Under Alternative 4**

| Area | Local Capture | Output | Jobs* | Labor Income | Value Added |
|---|---|---|---|---|---|
| **Local** | | | | | |
| Direct Impact | | $1,020,644,269 | 12630.2 | $848,862,339 | $556,303,208 |
| Secondary Impact | | $910,100,701 | 5557.0 | $300,314,646 | $517,852,788 |
| Total Impact | $1,020,644,269 | $1,930,744,970 | 18187.2 | $1,149,176,985 | $1,074,155,996 |
| **State** | | | | | |
| Direct Impact | | $1,057,229,501 | 13216.7 | $893,358,404 | $610,458,869 |
| Secondary Impact | | $1,231,762,758 | 6820.1 | $416,566,223 | $703,599,526 |
| Total Impact | $1,057,229,501 | $2,288,992,261 | 20036.8 | $1,309,924,627 | $1,314,058,393 |
| **US** | | | | | |
| Direct Impact | | $1,057,722,638 | 13314.0 | $907,118,160 | $621,836,173 |
| Secondary Impact | | $2,319,826,937 | 10726.8 | $720,301,589 | $1,249,422,042 |
| Total Impact | $1,057,722,638 | $3,377,549,575 | 24041.0 | $1,627,419,749 | $1,871,258,215 |

* Jobs are presented in full-time equivalence (FTE)

The estimated overall regional economic development impacts for Alternative 4 shown in Table 3.11-15 are explained by project in the following four paragraphs.

Foster and Green Peter - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Foster and Green Peter are estimated to be $65,247,000. Of this total expenditure, $62,887,632 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $65,247,000 support a total of 1,095.6 full-time equivalent jobs, $65,074,796 in labor income, $57,932,188 in the gross regional product, and $108,581,363 in economic output in the local impact area. More broadly, these expenditures support 1,503.5 full-time equivalent jobs, $100,045,084 in labor income, $115,214,432 in the gross regional product, and $208,245,312 in economic output in the nation.

Detroit and Big Cliff - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Detroit and Big Cliff are estimated to be $708,350,000. Of this total expenditure, $682,787,232 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $708,350,000 support a total of 12,328.6 full-time equivalent jobs, $776,074,533 in labor income, $712,788,909 in the gross regional product, and $1,285,254,820 in economic output in the local impact area. More broadly, these expenditures support 16,063.0 full-time equivalent jobs, $1,089,625,127 in labor income, $1,250,818,317 in the gross regional product, and $2,260,802,291 in economic output in the nation.

Cougar and Blue River- The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Cougar and Blue River are estimated to be $179,350,000. Of this total expenditure, $173,250,528 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $179,350,000 support a total of 3,001.0 full-time equivalent jobs, $194,079,607 in labor income, $191,185,839 in the gross regional product, and $338,291,203 in economic output in the local impact area. More broadly, these expenditures support 4,079.4 full-time equivalent jobs, $275,813,735 in labor income, $318,328,429 in the gross regional product, and $572,421,671 in economic output in the nation.

Hills Creek, Lookout Point, Dexter, Fall Creek - The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Hills Creek, Lookout Point, Dexter, and Fall Creek are estimated to be $105,300,000. Of this total expenditure, $101,718,877 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $105,300,000 support a total of 1,762.0 full-time equivalent jobs, $113,948,049 in labor income, $112,249,060 in the gross regional product, and $198,617,584 in economic output in the local impact area. More broadly, these expenditures support 2,395.1 full-time equivalent jobs, $161,935,803 in labor income, $186,897,037 in the gross regional product, and $336,080,301 in economic output in the nation.

**Population and Housing**

As discussed above in Section 3.11.2.4.1, given the current availability of approximately 21,100 housing units within the ROI (USCB 2019c), any small in-migration resulting from construction projects is not expected to substantially affect housing availability for current residents. As such, minor, adverse effects to population and housing would occur under Alternative 4. These effects would occur in the short and medium term and be regional in extent.

**Quality of Life and Recreational Value**

As discussed above in Section 3.11.2.4.1, work-related activities involving heavy equipment would cause visual and auditory disturbance to local residents and recreational users in the vicinity of the project areas, as well as reduce air quality from project-related emissions. Traffic levels would similarly increase during work periods, but would be confined to the immediate vicinity of work sites and would not substantially reduce resident access to community resources or visitor access to reservoirs. Work-related noise, emissions, and congestion would reduce resident quality of life and recreational value during the construction phases only and have local, adverse, moderate effects in the short and medium term. Long-term visual effects from the erection of new structures would be minor.

Although these works of improvement have been specifically designed to meet the requirements of ESA-listed species, their populations would not return to a level that would directly affect recreational fishing. However, other species including those within recreational fisheries would also benefit from improved habitat value. Recreational fishing use and visitation within the ROI would likely increase in the long term and have negligible, beneficial, indirect effects on the recreational value of affected reservoirs.

**Low-Income Populations**

Low-income populations in Lane, Linn, and Marion counties that are hired to work on these projects would experience minor health benefits through economic pathways in the short and medium term. There may also be minor adverse effects to the physical health and well-being of low-income communities (from increased air emissions and noise levels) that are hired to work at the sites for the duration of these projects, but these effects would not persist beyond the duration of the construction phase. Benefits would only persist for the duration of the construction and infrastructure improvement phases with only a small number of permanent maintenance jobs created; therefore, long-term beneficial effects would be negligible. All effects would be regional in extent.

*3.11.7.13.2 Alteration of outflows and reservoir levels*

The following measures would affect recreational value and reservoir levels.

- Fall Creek drawdown;
- Foster Fish Ladder Temperature Improvement (#479);

- Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) (GPR);
- Use of spillway for surface spill in summer (#721) (GPR);
- Augmentation of instream flows by using the inactive pool (#718) (CTG, DOR, FCR, BLU);
- Augmentation of instream flows by using the power pool (#304) (LOP, HCR, CGR, GPR, DET); and
- Integrated temperature and habitat flow regime (#30a) (All reservoirs).

**Quality of Life**

The Fall Creek Drawdown would continue to adversely affect the quality of life for nearby residents and the recreational value at Fall Creek in the short and long term (recurring). There are no cities directly on the shores of the Fall Creek Reservoir, so therefore effects to the quality of life would be minor and localized.

**Recreational Value**

Increased reservoir levels and alteration of outflows would increase both the quality of recreational opportunities offered at reservoirs and the ability of reservoirs to support increased numbers of visitors over the life of the project. Higher reservoir levels support higher levels of visitation, higher recreational quality, and higher recreational expenditures. These visitors would in turn generate minor, indirect, beneficial, socioeconomic effects through the expenditure of funds in support of their activity of choice for the life of the project. As a result of increased recreational opportunity and quality, average annual NED recreational benefits are expected to increase under Alternative 4 throughout the WVS. Increased recreational revenues attributable to Alternative 4 are also estimated to support 4.3 jobs and $301,000 in total value to the economy of the ROI. Hence, these regional, indirect beneficial effects would be minor and long-term.

**M&I Use and Irrigation**

Under Alternative 4, peak conservation storage would increase 122,000 acre-feet over the NAA and benefit water users throughout the WVS. Increased availability of irrigation water would allow for increases in the amount of irrigated acreage throughout the ROI and reduced prevalence of crop damages for the life of the project, stimulating indirect and induced socioeconomic benefits throughout the ROI as crops are brought to market. M&I users would also likely be able to use the majority of their water allocations, decreasing costs of living and business throughout the ROI for the life of the project. Hence, these beneficial effects would be minor, regional, and long-term.

**Non-Use and Existence Value**

As such, the overall beneficial effect to socioeconomic resources due to recreation and water supply as a result of the alteration of outflows and reservoir levels would be moderate in magnitude, medium in extent, long-term, and significant.

*3.11.7.13.3 Suite of Near-Term Operations*

Near-term operations that could affect socioeconomic resources include deep drawdowns, extended deep drawdowns, RO prioritization, and delayed reservoir refills for improved downstream fish passage. For reasons similar to those discussed above as they relate to recreational value; agricultural irrigation and M&I use; and quality of life, effects to socioeconomic resources would range from minor to moderate and adverse in the short term and long term (recurring). Visitation would likely further decrease due to decreased recreational quality of reservoirs and could affect recreational revenues. Costs to agricultural and M&I users would further increase due to reduced WVS water availability; and the loss of surface water would adversely affect the viewshed for nearby residents for longer than three weeks.

The suite of near-term operations would also further augment fish spawning and rearing habitat, improve instream water quality by ensuring instream temperature and TDG control, ensure adequate streamflow for biologically justified flows, and improve fish passage. As such, the implementation of these near-term operations would have indirect, minor beneficial effects to the recreational value in the long-term.

*3.11.7.13.4 Climate change*

As discussed in Section 3.11.2.3.1, climate change is expected to result in wetter winters (where more precipitation falls as rain rather than snow), less snowpack, drier summers, increased air and water temperatures, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB, independent of the O&M of the WVS over the next 30 years. These factors would contribute to indirect adverse effects to socioeconomic resources throughout the entirety of the ROI through decreased recreational revenues resulting from lower recreational quality and visitation as well as increased costs to irrigation and M&I.

Under Alternative 4, construction measures would cause adverse effects to population and housing with an in-migration of workers to the ROI. Increased capital expenditures would benefit labor and earnings and low-income populations. Climate change would not exacerbate these effects and the magnitude, extent, and duration would remain the same. Effects to the recreational value and viewshed (and therefore quality of life) from construction activities and the Fall Creek Drawdown could be exacerbated if wildfires and HABs further affect turbidity and water quality. However, effects from construction activities and the Fall Creek drawdown in combination with climate change would likely remain moderate, localized, and occur in the short, medium, and long term (recurring).

Under Alternative 4, beneficial effects resulting from increased reservoir storage would be minor, regional, and long term. These beneficial effects would offset the adverse effects from climate change on recreational value and water supply described above. As such, the alteration of outflows and reservoir levels in combination with climate change would have long term, regional, negligible to minor, beneficial effects.

#### *3.11.7.14 Alternative 5 – Integrated Water Management and ESA-Listed Fish Alternative (using diversion tunnel at CGR)*

Alternative 5 is nearly identical to Alternative 2B and differs only in its use of a refined integrated temperature and habitat flow regime (#30b). Given their similarity, the socioeconomic effects of the Alternatives are essentially identical to those and are affected by the same mechanisms discussed in Section 3.11.2.6; the use of integrated temperature and habitat flow regime only affect biologic and hydrologic parameters and would not noticeably affect socioeconomic resources differently from Alternative 2B.

Under Alternative 5, beneficial socioeconomic effects to labor and earnings and low-income populations due to construction and maintenance of structural measures would be negligible to minor in magnitude, regional in extent, short-term and medium-term. Adverse effects to population and housing would be negligible to minor, regional in extent, and short- and medium-term in duration. Adverse effects to quality of life and recreational value from construction would be minor in magnitude, regional in extent, and occur in the short and medium term. Long-term visual effects to quality of life from the erection of new structures would be negligible to minor. Beneficial, indirect effects to recreation expenditures from the alteration of outflows and reservoir storage measures under Alternative 5 would be negligible in magnitude, regional in extent, and long-term. Indirect, adverse effects to M&I and agricultural water supply costs from the alteration of outflows and reservoir storage measures under Alternative 5 would be minor in magnitude, regional in extent, and long-term. Preserving the existence value of the UWR Chinook salmon and UWR steelhead would have long-term, minor beneficial effects to society in the state and beyond. Alternative 5 would have nearly identical affects as Alternative 2B, similar effects to socioeconomic resources as Alternatives 2A, and would have effects of substantially lower magnitude than Alternatives 1, 3A, 3B and 4.

##### *3.11.7.14.1 Construction, Operation, Management, Rehabilitation, and Replacement of Structural Measures*

The same measures as those under Alternative 2B would be occur under Alternative 5, resulting in beneficial and adverse socioeconomic effects through the mechanisms discussed in Section 3.11.4.2.1.

- Gravel augmentation below dams (#384) (CGR, BLU, FOS, BCL);
- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) (All reservoirs);

- Maintenance of existing and new fish release sites above dams (#726) (DET, BCL, GPR, FOS, CGR, HCR, FCR, LOP);
- Foster Fish Ladder Temperature Improvement (#479) (FOS);
- Construction of WTC towers (#105) (DET);
- Use of regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) (GPR);
- Use of spillway for surface spill in summer (#721) (GPR);
- Construction of AFFs (#722) (GPR);
- Provide Pacific lamprey passage and infrastructure (#52) (GPR);
- Construction of structural downstream fish passage (#392) (LOP, FOS, DET); and
- Operation, Maintenance, Repair, Replacement, and Rehabilitation. (All reservoirs)

**Labor and Earnings**

Given their functional similarity, the socioeconomic effects of Alternatives 5 and 2B are very similar and are affected by the same mechanisms discussed in Section 3.11.2.4. Construction costs would not appreciably differ between these alternatives and it is not likely implementation of either alternative would substantially alter the support of jobs or noticeably increase consumer demand within the ROI. As such, beneficial socioeconomic effects due to increased construction expenditures under Alternative 5 would be negligible to minor in magnitude in the short-term, increasing to major in the medium term while construction is occurring, and regional in extent.

**Population and Housing**

As discussed above in Section 3.11.2.4.1, given the current availability of approximately 21,100 housing units within the ROI (USCB 2019c), any small in-migration resulting from construction activities under Alternative 5 could be measurable and could be noticeable but would not affect housing availability or pricing for current residents. Any adverse effects which may occur would only persist for the short- or medium-term duration of the construction period depending on the scale of the project in question. As such, adverse effects on population and housing would be negligible to minor and regional in extent.

**Quality of Life and Recreational Value**

Quality of life and recreational value of reservoirs would be minorly reduced in the vicinity of project sites during the construction due to the visual disturbance from the presence of heavy equipment and workers, increased air emissions, noise and traffic. Effects would be confined to the immediate vicinity of project sites (reservoirs and towns bordering reservoirs) and would only persist for the duration of construction projects. These effects would be most pronounced in the towns of Detroit and Sweet Home, in particular due to the construction of a WTC tower at Detroit and construction of structural downstream fish passages at Detroit and Foster; both of which are relatively larger projects that would occur in the medium-term. As such, effects to quality of life and recreational value due to construction-related activity under Alternative 5 would be short- and medium-term, localized, and major.

Although these works of improvement have been specifically designed to meet the requirements of ESA-listed species, their populations would not return to a level that would directly affect recreational fishing. However, other species including those within recreational fisheries would also benefit from improved habitat value. Recreational fishing use and visitation within the ROI would likely increase in the long term and have negligible, beneficial, indirect effects on the recreational value of affected reservoirs.

**Low Income Populations**

Low-income populations in Lane, Linn, and Marion counties that are hired to work on these projects would experience negligible to minor health benefits through economic pathways in the short and medium term. There may also be negligible to minor adverse effects to the physical health and well-being of low-income communities (from increased air emissions and noise levels) that are hired to work at the sites for the duration of these projects, but these effects would not persist beyond the duration of the construction phase. Benefits would only persist for the duration of the construction and infrastructure improvement phases with only a small number of permanent maintenance jobs created; therefore, long-term beneficial effects would be negligible. All effects would be regional in extent.

#### *3.11.7.14.2 Alteration of outflows and reservoir levels*

The following measures would affect recreational value and reservoir levels.

- Fall Creek drawdown;
- Foster Fish Ladder Temperature Improvement (#479) (FOS);
- Use of regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) (GPR);
- Use of spillway for surface spill in summer (#721) (GPR);
- Augmentation of instream flows by using the inactive pool (#718) (FCR, BLU);
- Augmentation of instream flows by using the power pool (#304) (LOP, HCR, GPR, DET);
- Refined integrated temperature and habitat flow regime (#30b) (All reservoirs);
- Deeper fall reservoir drawdowns for fish passage (#40) (CGR, GPR);
- Spring reservoir drawdown for downstream fish passage (#720) (CGR); and
- Pass water over spillway in spring for fish passage (#714) (GPR).

**M&I Use and Irrigation**

Similar to Alternative 2B, Alternative 5 would result in a decrease of 64,000 acre-feet of conservation storage from the NAA. Reduced conservation storage would increase water costs and crop damages to M&I and irrigation users throughout the ROI, resulting in general cost of living increases for the life of the project. These regional, indirect, adverse socioeconomic effects would be minor and long-term.

**Recreational Value**

As described under Alternative 2B, deep fall reservoirs draw-downs at Green Peter would likely decrease visitation in the short term but would not likely affect revenues due to seasonally low levels of visitation during this timeframe. Spring drawdowns in particular at Cougar Reservoir would reduce recreational expenditures at this reservoir due to decreased recreational quality during the spring recreation season throughout the life of the project. However, Cougar is one of the least visited reservoirs of the 13 reservoirs; and visitors spend the least amount of dollars per visit at this reservoir (USACE 2019g). Hence, these short- and long-term (recurring) adverse effects from drawdowns at Fall Creek, Green Peter, and Cougar would be negligible and localized.

Conversely, fall and spring reservoir drawdowns would negligibly increase habitat values for recreational fish species throughout the ROI for the life of the project, resulting in increased recreational visitation and expenditures. Average annual NED benefits under Alternative 5 would be slightly higher than the NAA; these benefits would support 5.2 jobs and $356,000 in total economic value. These regional, beneficial effects would ultimately be negligible in magnitude and long-term.

**Quality of Life**

As discussed above in Section 3.11.2.4.2, drawdowns under this alternative would also adversely affect the quality of life for nearby residents at Fall Creek and Green Peter. Additionally, under this alternative, deep fall and spring reservoirs drawdowns at Cougar would similarly affect the quality of life for nearby residents. There are no cities directly on the shores of Fall Creek, Green Peter, or Cougar and therefore effects to the quality of life would be minor and localized. Effects would occur in the short term and recur annually in the long term.

**Non-Use and Existence Values**

As discussed above in Section 3.11.2.4.3, implementation of the measures under Alternative 2A would preserve the existence value of the UWR Chinook salmon and UWR steelhead and therefore have long-term, minor beneficial effects to society.

*3.11.7.14.3 Suite of Near-Term Operations*

Near-term operations that could affect socioeconomic resources include deep drawdowns, extended deep drawdowns, RO prioritization, and delayed reservoir refills for improved downstream fish passage. Visitation would likely further decrease due to decreased recreational quality of reservoirs and could affect recreational revenues. Costs to agricultural and M&I users would further increase due to reduced WVS water availability; and the loss of surface water would adversely affect the viewshed for nearby residents for longer than three weeks. As such, socioeconomic effects as they relate to recreational value; agricultural irrigation and M&I use; and quality of life would range from minor to moderate and adverse in the short term and long term (recurring).

The suite of near-term operations would also further augment fish spawning and rearing habitat, improve instream water quality by ensuring instream temperature and TDG control, ensure adequate streamflow for biologically justified flows, and improve fish passage. As such, the implementation of these near-term operations would have indirect, minor beneficial effects to the recreational value in the long-term.

#### *3.11.7.14.4 Climate Change*

As discussed in Section 3.11.2.3.1, climate change is expected to result in wetter winters (where more precipitation falls as rain rather than snow), less snowpack, drier summers, increased air and water temperatures, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB, independent of the O&M of the WVS over the next 30 years. These factors in combination with decreased reservoir storage under Alternative 5 would contribute to indirect adverse effects to socioeconomic resources throughout the entirety of the ROI through decreased recreational revenues resulting from lower recreational quality and visitation as well as increased costs to irrigation and M&I. These adverse effects would be additive, long term, and minor to moderate.

Under Alternative 5, effects to visitation and the viewshed (and therefore quality of life) from construction activities and the Fall Creek, Green Peter, and Cougar drawdowns could be exacerbated if wildfires and HABs further affect turbidity and water quality. However, effects from construction activities and drawdowns in combination with climate change would likely remain minor, localized, and occur in the short, medium, and long term (recurring).

### ***3.11.7.15 Conclusion***

Reservoir drawdowns would be a main component of alternatives 3A and 3B, with a total of 10 drawdowns across seven reservoirs per year. As such, Alternatives 3A and 3B3B would cause the most severe short and long term adverse effects to quality of life, recreational value, and agricultural irrigation and M&I use; followed by alternatives 2A, 2B, and 5. In contrast, Alternatives 1 and 4 would consist largely of the construction structural measures and due to their high construction expenditures, would cause the most beneficial short- and medium-term effects to labor and earnings, as well as the most adverse short-and medium-term effects to population and housing and quality of life to workers. Alternatives 2A, 2B, and 5 consist of a combination of construction and reservoir drawdowns which allow for both beneficial effects due to construction expenditures without compromising the ability of WVS reservoirs to fulfill other authorized purposes.

## 3.12 POWER GENERATION AND TRANSMISSION AFFECTED ENVIRONMENT

The Willamette River Basin (WRB) contains several federal and non-federal hydroelectric facilities used to generate electrical energy for local and regional consumption, as well as high-voltage transmission lines and other facilities that move this energy from the generating facilities to local and regional loads.

The Flood Control Acts of 1948, 1950, 1954 modified the Flood Control Act of 1938 to provide for the installation of hydroelectric power-generating facilities at eight Corps multipurpose projects throughout the Willamette Basin: Detroit, Green Peter, Lookout Point, Cougar, Hills Creek, Big Cliff, Foster, and Dexter dams. These are a subset of the Federal Columbia River Power System (FCRPS) projects. The Corps dictates the parameters for dam operations to meet its statutory requirements, and power generation is subsequently scheduled within these parameters. The Cougar, Hills Creek, Big Cliff, Foster, and Dexter projects run a flat generation schedule each day based on the water available, and the generation schedule is determined solely by the Corps. For the Detroit, Green Peter, and Lookout Point projects, the Bonneville Power Administration (Bonneville) is provided an opportunity to optimize the daily timing of power generation after the Corps determines its statutory requirement needs for other project purposes, such as flood control and fish and water quality operations and identifies how many hours of generation would be available within a day, as well as any constraints (e.g., cannot be more than 10 continuous hours without generation).

Bonneville is a federal power marketing administration designated by statute to sell power and transmission services throughout the Pacific Northwest region. Bonneville sells electric power from FCRPS projects, operated and maintained by other federal agencies (i.e., Corps or Reclamation), to its regional firm power customers (wholesale power customers) across the Pacific Northwest, including municipalities, public utility districts (PUDs), cooperatives, federal agencies, and investor-owned utilities (IOUs) and one direct service industry customer. These wholesale power customers, in turn, serve residential, commercial, and industrial retail customers (i.e., “end users”).

Bonneville also operates and maintains about 15,000 circuit miles of the high-voltage transmission system within the Pacific Northwest region (Bonneville 2013). This system integrates and transmits electric power within the Pacific Northwest region and interconnects with external transmission systems throughout the western United States and parts of Canada and Mexico. Separate from its power sales, Bonneville sells transmission services (for the delivery of electricity from generating resources to end users) and associated ancillary services (for maintaining transmission system reliability) to regional firm power customers, independent power producers, and power marketers.

There are non-federal hydropower generation projects in the Willamette Valley upstream or downstream of the WVS projects, most of which are licensed by the Federal Energy Regulatory Commission (FERC) (Table 3.12-1). The Eugene Water and Electric Board (EWEB) owns and operates two run-of-river hydroelectric projects on the McKenzie River: Carmen-Smith and Leaburg-Walterville (Figure 3.12-1). EWEB's Carmen-Smith project is located close to the origination of the McKenzie River at Clear Lake; its operation is independent of other generation projects in the Willamette Valley. Downstream of the Corps' Cougar and Blue Lake projects, EWEB diverts McKenzie River flows to the Leaburg Power Canal and the Walterville Power Canal for hydropower generation at the Leaburg and Walterville generation facilities, and then returns these flows to the river. The Santiam Water Control District (SWCD) operates a small hydropower project at their facilities at Geren Island (185 kilowatt) in the Santiam River downstream of Detroit Dam, and is in the process of licensing additional generation capacity. In 2013, private developers built a 7.5 MW power house that uses discharges from the Dorena Project. Portland General Electric operates a 15 MW facility at Willamette Falls.

Under section 10(f) of the Federal Power Act, non-federal hydropower projects downstream of federal storage reservoirs are required to pay a portion of the storage costs of the upstream federal projects for the use of improved stream flows which increase their project's generation (referred to as "energy gains"). The payments for these energy gains are known as headwater benefit payments. In the Willamette Valley, this applies to Leaburg/Walterville and Willamette Falls. Both Portland General Electric and Eugene Water and Electric Board make annual payments and their recent 5-year average (2017-2021) energy gains and headwater benefit payments are depicted in Table 3.12-1.

**Table 3.12-1 Non-Federal hydropower projects in the Willamette Valley.**

| Project | Owner | FERC License No. | River Basin | MW | Energy Gains (aMW)[1, 2] | Headwater Benefit Payment[1] |
|---|---|---|---|---|---|---|
| Carmen- Smith | Eugene Water and Electric Board (EWEB) | 2242 | McKenzie | 92.00 | NA[3] | NA[3] |
| Leaburg/ Walterville | EWEB | 2496 | McKenzie | 23.90 | 0.84 | $8,400 |
| Dorena Lake Dam | Dorena Hydro, LLC | 11945 | Row | 7.50 | NA[3] | NA[3] |
| Geren Island | Santiam Water Control District | Exempt | North Santiam | 0.19 | NA[3] | NA[3] |
| Willamette Falls | Portland General | 2233 | Willamette | 16.00 | 2.94 | $26,600 |

1/Annual amount averaged over a five-year period (2017-2021).

2/The aMW for energy gains does not represent an increase in average annual generation. Instead, it is a weighted average to account for differences in critical period generation and average energy with their respective values multiplied by 1 and 2.

3/Energy gains and headwater benefit payments do not apply to projects that are upstream of federal storage projects or are not functionally downstream of federal projects (i.e., Carmen-Smith and Dorena Lake Dam, respectively) or are FERC exempt (Geren Island).

Congress created Bonneville through enactment of the Bonneville Project Act in 1937, Pub. L. No. 75-329, 50 Stat. 731 (codified as amended at 16 U.S.C. §§ 832-832m (2012)) to market and transmit electric power produced by federal hydropower dams in the Pacific Northwest.

Bonneville is statutorily obligated to assure the Pacific Northwest of an adequate, efficient, economical, and reliable power supply consistent with Section 839(3) of the Northwest Power Act. Bonneville's authority to market power generated from the entire FCRPS[19], of which the Willamette Valley System (WVS) hydropower dams are a subset, is codified in Section 8 of the Federal Columbia River Transmission System Act of 1974, Pub. 93-454, 88 Stat. 1376, (codified as amended at 16 USC §§ 838-838l (2012)). The Federal Columbia River Transmission System Act also gave Bonneville express authority to operate and maintain the Federal Transmission System within the Pacific Northwest and to construct improvements, betterments, and additions to and replacements of the system. The terms and rates upon which Bonneville may sell power and transmission services are subject to several statutes, including the Bonneville Project Act, the Flood Control Act of 1944, Pub. L. No. 78-534, 58 Stat. 887 (codified at 16 U.S.C. § 825s (2012)), the Federal Pacific Northwest Consumer Power Preference Act of 1964, Pub. L. No. 88-552, 78 Stat. 756 (codified at 16 U.S.C. §§ 837-837h (2012)), the Federal Columbia River System Transmission Act of 1974, and the Pacific Northwest Electric Power Planning and Conservation Act, 1980, Pub. L. No. 96-501, 94 Stat. 2697 (codified at 16 U.S.C. § 839-839h (2012)).

### 3.12.1 Affected Environment

Sections 3.12.2.1 through 3.12.2.4 describe the federal power and transmission systems, focusing on those elements that could be affected by the alternatives of the Draft WVS EIS.

#### *3.12.1.1 Federal Power*

Bonneville sells firm power at wholesale under long-term contracts to 136 power customers within a 300,000-square-mile service area in the Pacific Northwest. The Bonneville service area is geographically located within the boundary of the Western Interconnection power system. The Western Interconnection is one of four major North American power systems and includes power generation and transmission facilities across 14 U.S. states, two Canadian provinces, and parts of Mexico (WECC 2018). Bonneville imports power and exports surplus power (i.e., power not needed to meet Bonneville's firm power commitments) beyond the Pacific Northwest but within the Western Interconnection.

In understanding power generation, it is important to recognize that "capacity" is distinct from "energy," and that the Alternatives have the potential to affect them in different ways. Capacity is defined as the maximum potential output of a generation unit that can be physically produced at any given instant and is commonly expressed in megawatts (MW). Generators do not operate at full capacity at all times, and output can vary according to a variety of factors such as lower demand, market conditions, and variability in fuel sources. In this context, energy is defined as the amount of electric power generated at a project or power plant over a period of time and is expressed in megawatt-hours (MWh) or average megawatts (aMW). An aMW is a

[19] The FCRPS consists of the Federal transmission system and 31 Federally-owned dams on the Columbia River and its tributaries including eight WVS Projects with hydropower.

unit of energy representing 1 MW of electric power capacity generated continuously over a year. One aMW is equal to 8,760 MWh.

Table 3.12-2 provides a summary of the power-generating capacity within the Western Interconnection, the Pacific Northwest, all of Bonneville's marketable resources, and WVS projects. For each of these areas, the values summarized in Table 3.12-2 are not additive; the smaller areas are a subset of the larger areas (i.e., the Pacific Northwest is a subset of the Western Interconnection, Bonneville's marketable resources are a subset of the Pacific Northwest, and the WVS projects are a subset of Bonneville's marketable resources). In addition, power generating projects typically operate below full capacity primarily because of the variation in available resources (e.g., water, wind, solar, etc.), demand for electric supply, and constraints on project operation to achieve non-power objectives, as well as for any applicable Ancillary Services (e.g., Incremental Capacity, Decremental Capacity, synchronous condensing, etc.). Both capacity and energy existing conditions and trends for these areas are further explained in the discussion below.

- Western Interconnection Resources: The diverse mix of generation resources, referred to as a "resource mix," in the Western Interconnection constitutes roughly 20 percent of all national power generation, with approximately 40 percent of all national hydropower capacity and 35 percent of all wind and solar capacity. Given the geographic, climatic, and consumer (e.g., urban and rural, residential, commercial, and industrial electricity end users) diversity across the Western Interconnection, demand for and generation of power varies greatly. Coordination across the Western Interconnection allows for planning across this diverse power system to ensure cost-effective and reliable power. Overall, across the Western Interconnection for 2016, there were 94,863 aMW generated, of which hydropower generated roughly 26,000 aMW (WECC 2018).
- Pacific Northwest Regional Resources: The Pacific Northwest regional resources are a component of the Western Interconnection resources. Table 3.12-2 illustrates the predominance of hydropower capacity (54 percent) in the resource mix of the Pacific Northwest region. In Figure 3.12-1 total power generation (energy) in the Pacific Northwest fluctuated year to year between 2006 and 2019 (NW Council 2021). Wind energy production has been increasing during this period. The region is experiencing a rapid growth in new renewable generation, primarily wind and solar, largely developed by independent power producers, spurred in part by recent legislative and policy trends.
- Bonneville's Marketable Resources: Bonneville does not own generating resources, rather, Bonneville markets power from a combination of federal resources (31 FCRPS dams), certain non-federal generating resources (e.g., wind, hydro, nuclear, etc.) whose output Bonneville has acquired under contracts, and other contract purchases, as needed. Table 3.12-2 illustrates the predominance of hydropower generation capacity (94 percent) in the mix of all Bonneville's marketable resources.
- WVS Projects: The eight WVS projects with hydropower that are the subject of the WVS EIS are a subset of the 31-project FCRPS. Each of these eight WVS projects has one or more generation units with a specific capacity to produce power. The nameplate capacity (i.e.,

the maximum potential for energy output) for each WVS project ranges from 21 to 138 MW. Table 3.12-3 lists these projects and their generating characteristics. The total combined capacity of these eight WVS projects is 469 MW. This represents about two percent of the 22,441 MW nameplate capacity of the FCRPS. Average generation at these eight projects combined is 171.4 aMW, which constitutes less than two percent of the total energy of the FCRPS.

**Table 3.12-2. Power Generation Capacity in Megawatts (Current as of 2021).**

| Type | Western Interconnection | Pacific Northwest Region | Bonneville[1] | Willamette Valley System |
|---|---|---|---|---|
| Hydropower | 72,000 | 34,650 | 22,441[2] | 469 |
| Wind | 23,000 | 10,710 | 248 | 0 |
| Natural Gas | 102,000 | 9,450 | 0 | 0 |
| Coal | 37,000 | 5,040 | 0 | 0 |
| Solar | 16,000 | 1,260 | 0 | 0 |
| Nuclear | 8,000 | 1,260 | 1,144 | 0 |
| Geothermal | 3,000 | 61 | 0 | 0 |
| Other | 9,000 | 569 | 0 | 0 |
| **Total Capacity** | **270,000** | **63,000** | **23,833** | **469** |

Source: Bonneville (2019), WECC (2018), NW Council (2021)

Note: The estimates across geographic regions are not additive; the Pacific Northwest is geographically within the Western Interconnection. The WVS Projects' capacity is for the eight WVS projects with hydropower facilities that would be affected by the Alternatives, which are a subset of the Bonneville resources.

[1/] This column (Bonneville) represents the generation capacity of all of Bonneville's marketable resources.

[2/] This statistic (Bonneville hydropower) represents the total capacity of the FCRPS' hydropower system, inclusive of the WVS projects, from a total of 196 hydro generating units.

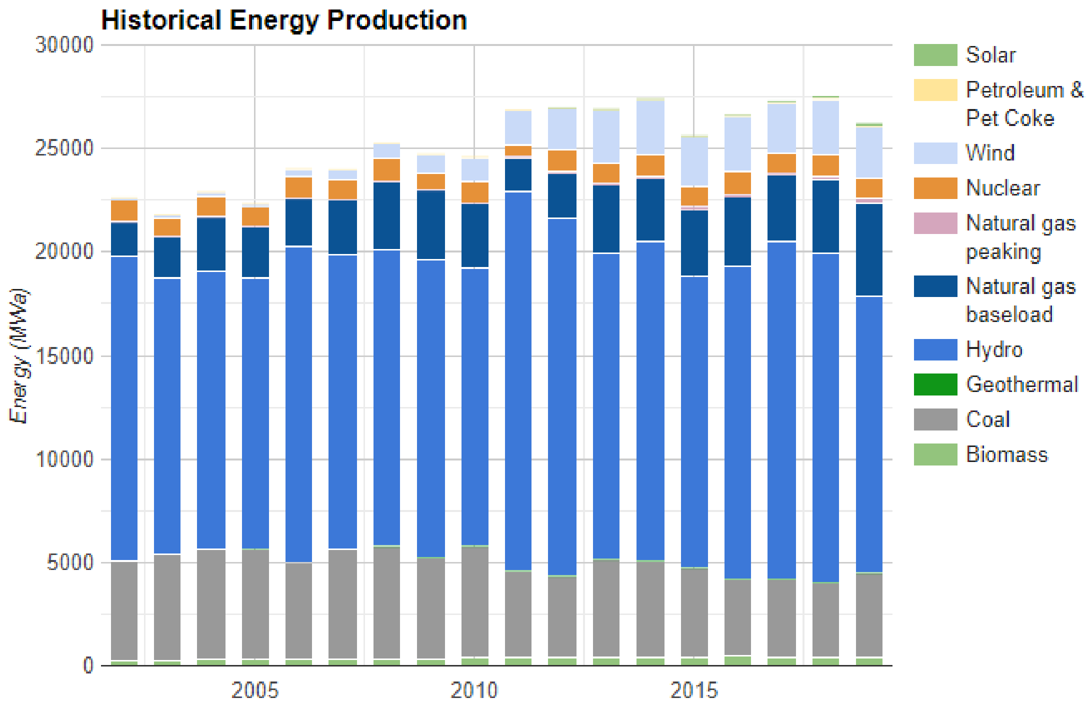



**Figure 3.12-1 Breakdown of Annual Generation in the Pacific Northwest by Type from 2002 to 2019. Source: NW Council (2021).**

**Table 3.12-3. Power Generation Characteristics of the eight Willamette Valley Projects with Hydropower Facilities.**

| Plant | Number of Units | Capacity (MW) | Average Generation (aMW) |
|---|---|---|---|
| Big Cliff | 1 | 21 | 11 |
| Detroit | 2 | 115 | 37 |
| Dexter | 1 | 17 | 10 |
| Foster | 2 | 23 | 11 |
| Green Peter | 2 | 92 | 28 |
| Hills Creek | 2 | 34 | 18 |
| Lookout Point | 3 | 138 | 41 |
| Cougar | 2 | 29 | 16 |
| **Total** | **15** | **469** | **171** |

Note: 73-years average generation, 1936 to 2008

Capacity Source: 2019 Bonneville White Book

#### *3.12.1.2 Regional Power Supply and Reliability*

"Power system reliability" refers to the ability of the power supply to meet the demand, and demand for power is typically referred to as "load." The flexibility and capacity of the hydropower system is critical to ensuring power system reliability. Power system reliability is measured and discussed in terms of "loss of load probability" (LOLP) of a region's power supply. LOLP reflects the probability that the region's expected supply of power would not be able to meet the region's demand for electricity. The NW Council sets the metric (e.g., LOLP) and target for reliability for the Pacific Northwest. Created by the Northwest Power Act in 1980, the NW Council develops both a regional power plan and the Columbia River Basin Fish and Wildlife Program, which collectively "ensure, with public participation, an affordable and reliable energy system while enhancing fish and wildlife in the Columbia River Basin."[20] The current target for LOLP set by the NW Council in 2011 is five percent, meaning the power supply should have sufficient resources (both capacity and energy) to limit the likelihood of a shortfall to no more than five percent during a future year, taking into account, for example, cold snaps in winter and heat waves in summer. To measure adequacy, LOLP is calculated by dividing the number of simulations with shortfalls by the total number of simulations studied. For the power supply to be deemed adequate, that fraction must be less than 1/20, equating to an LOLP of five percent or less. When the power supply is unable to meet demand, customers could experience blackouts for brief or extended periods of time.

Electricity production at the WVS projects is influenced both by the turbine capacity and the amount of water available for generation. The amount of water available at each hydro project varies from year to year, season to season, day to day, and even hour to hour based on variation in flows and operational constraints. The Corps provides daily operational guidance to Bonneville for scheduling power generation for a specific number of hours each day. The WRB is primarily rain based, and the projects are operated to manage floods fall through spring. Flood risk management in the WRB is accomplished by drafting the reservoirs behind the dams to low levels in the late fall before the rains start to provide storage space to retain inflow during downstream flood events. The release of any retained water during the flood season is regulated by the flow levels at downstream control points such as Albany and Salem whenever possible. After the flood season has passed, the reservoirs are filled with the spring inflows to their maximum conservation season level. Summer is climatically very dry, and the outflows are set for recreation, flow objectives for fish and wildlife, water quality, and irrigation. The eight projects that generate hydropower have minimal capability to shape generation to load. This cycle of drafting and filling is guided by a "Rule Curve" at each storage project that specifies the timing of each of these phases of regulation. The Rule Curve is the pool elevation that the reservoir is managed to stay at or below when possible, with pool levels above the curve when operating for flood risk management, and pool levels below the curve when inflows are low and the stored water is released to meet the various needs of the system. Consequently, the ability

[20] See NW Council, https://www.nwcouncil.org/about/mission-and-strategy. The Council uses the term "standard," but because this is not an enforceable standard, the EIS refers to this as a "target."

to manage the timing of water flow through the WVS projects for power purposes is limited to within each day.

#### *3.12.1.3 Multipurpose System and Economical Power Supply*

As a multipurpose system, the FCRPS produces both power and non-power benefits for the Pacific Northwest and facilities are owned and operated by either the Corps or Reclamation. The Corps and Reclamation operate and maintain their respective FCRPS facilities with a combination of Bonneville direct funding and federal appropriations. Bonneville solely funds activities related to power generation and jointly funds activities that support the shared purposes of the facilities.

As described in Section 3.12.2.1, the FCRPS consists of 196 hydro generating units with a total capacity of 22,441 MW, making it the largest hydro system in the United States (EIA 2014). For decades, it has been an engine of economic prosperity. It provides low-cost, carbon-free electricity, flood risk mitigation, irrigation, navigation, water quality, municipal and industrial water supply, and recreational opportunities throughout the region.

Effective management of FCRPS facilities requires balancing the many uses of these shared resources as efficiently as possible. A joint agency asset management strategy is used to make decisions that maximize the value of the FCRPS as a whole while meeting each agency's various obligations. This means identifying optimal investment timing to mitigate safety, environmental and financial risks, tailoring maintenance programs to the level of service necessary to meet obligations, and efficiently planning and operating the power system.

Congress mandated that Bonneville provide a reliable and economical power supply consistent with its statutory obligations, Bonneville continuously evaluates external factors and risks that affect its ability to bring the benefits of reliable, affordable, and clean electricity to Northwest communities.

In the WVS, the FCRPS facilities are all operated and maintained by the Corps for multiple congressionally authorized purposes, but chiefly for flood risk management. As a subset of the FCRPS and as described in Section 3.12.2.1, the WVS consists of 15 hydro generating units, apportioned to eight dams, with a total capacity of 469 MW. Accordingly, the WVS contributes a small portion, less than 2%, of the total energy of the FCRPS.

In the WVS, using revenues from its electric power rates, Bonneville pays the Corps for its share of operation and maintenance and capital repayment costs based on the power allocation of each project, as determined by congressionally authorized purposes. The FCRPS dams in the WVS have historically operated, and continue to operate, at a higher cost relative to other FCRPS hydroelectric facilities; as such, the Willamette projects as they are operated today are increasingly marginal in their ability to facilitate Bonneville's efforts to provide an economical power supply to the region. Table 3.12-4 shows the three-year average cost of power metrics from 2018-2020 under expected generation from the 2019 Bonneville White Book. The "Cost of Generation" identified in Table 3.12-4 is a measure of the direct-funded capital, and operations and maintenance costs at the facilities. "Fully Loaded Costs" identified in this table include everything in the Cost of Generation plus allocations for all remaining Bonneville power-related costs such as its fish and wildlife program, residential exchange, and other overheads.

**Table 3.12-4. Three-year Average Cost of Power Metrics (Cost of Generation and Fully Loaded Cost) at Average Water Conditions**

| Strategic Class | Cost of Generation[1] ($/MWh) | Fully Loaded Cost[2] ($/MWh) |
|---|---|---|
| Main Stem Columbia | 7.75 | 18.30 |
| Lower Snake | 14.63 | 27.42 |
| Headwater | 13.08 | 23.51 |
| Area Support | 24.80 | 35.53 |
| Area Support - Willamette Valley | 25.28 | 43.16 |
| Local Support | 31.02 | 41.57 |
| **FCRPS Hydro** | **9.48** | **20.70** |

Source: Bonneville 2019 White Book

1/ Cost of Generation represents the Bonneville direct funded costs associated with producing power at a plant. Includes operations, maintenance, administrative, and capital-related costs (interest expense).

2/ Fully Loaded Cost includes the Cost of Generation plus allocations for all remaining Power Services costs attributable to the FCRPS (including Fish and Wildlife). The majority of these costs are system-wide costs that would still be incurred and reapportioned across other Strategic Classes if the power purpose for any individual dam were eliminated.

Given Table 3.12-4 amounts, the current cost-effectiveness of WVS projects is marginal relative to average market prices and other alternative resources. Recent court-ordered changes in operations at several WVS projects are likely to significantly increase the Cost of Generation at several WVS generation facilities while also significantly reducing the amount of electricity generated. Future capital requirements for generating unit modernizations and structural measures are expected to further diminish the cost-effectiveness of WVS projects' power production. Generally, Bonneville does not regard as cost effective measures that would result in a production cost higher than value of electricity generated at individual or group projects.

#### *3.12.1.4 Transmission*

Bonneville's transmission system connects and moves power generated from federal and non-federal dams; nuclear, natural gas, and coal-fired power plants; and solar and wind generation projects to loads throughout the Pacific Northwest and beyond. Bonneville owns and operates about 15,000 circuit miles of high-voltage transmission lines and associated substations in the Pacific Northwest. There are over 260 Bonneville substations that collect power, control its flow, and deliver electricity to Bonneville customers. As shown in Figure 3.12-2, Bonneville's transmission system contains multiple "paths," or routes over which power flowing from one point to another is monitored and managed.[21]

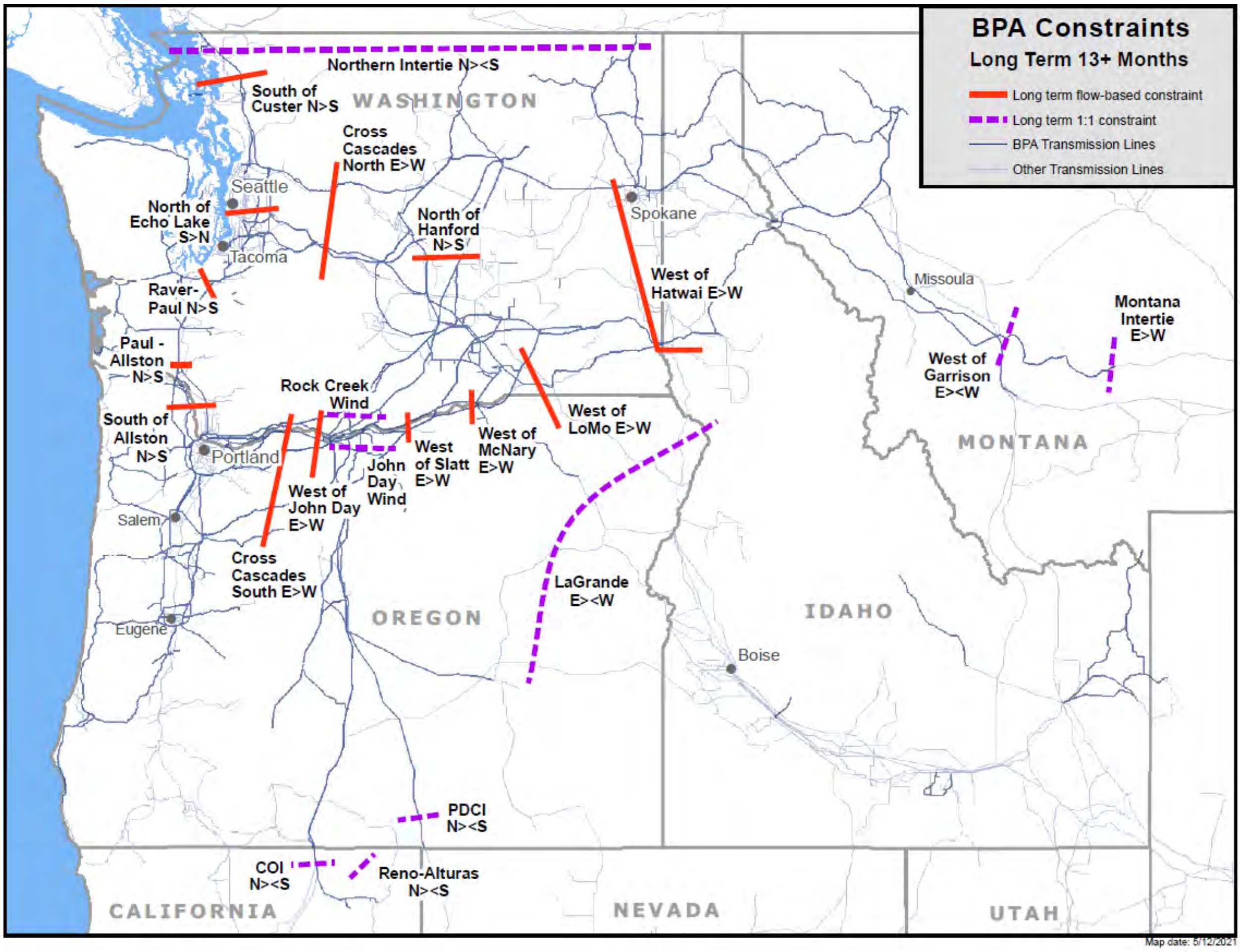



**Figure 3.12-2. Northwest Transmission Paths. Source: Bonneville (2021)**

Note: Blue lines represent Bonneville transmission lines, light gray-blue lines represent non-Bonneville transmission lines, and red and dashed purple lines denote defined paths and interties (locations where power flows are monitored and analyzed).

### *3.12.1.4.1 Bonneville Transmission Flows and Load Areas*

Bonneville's portion of the bulk electric power system (BES) is planned, designed, maintained, and operated to interconnect federal and non-federal generation to the major load centers in both the Pacific Northwest and externally to the major load centers in the WECC region. There is little generation in the Willamette Valley, so power is transmitted from generators located primarily east of the Cascades. The transmission lines that are primarily used for serving loads in the Willamette Valley run approximately from The Dalles, Oregon to substations between Portland and Salem (the "Cross Cascades South" corridor), and then south along the I-5

[21] See glossary for additional definitions of transmission paths and interties.

corridor. This corridor is considered congested,[22] especially in the winter months when loads tend to be highest. There is a notable transmission path that connects thermal generation in the Longview area, and other generators as far north as Olympia, to Portland called "South of Allston" which is also considered congested. A southern transmission path to the Klamath Falls area ties into the Pacific AC intertie, but has limited capacity to serve load in the Willamette Valley.

Changes in generation at the Willamette Valley dams tend to incrementally impact the congested paths of South of Allston and Cross Cascades South as power from generators east of the Cascades is then expected to balance any changes. Seasonal conditions further affect these transmission path capacities; because resulting temperature differences change the line ratings of all transmission paths while changes in generation patterns due to spring runoff and availability of wind and solar impact transmission path flows across the entire network, including paths that serve the Willamette Valley.

###### *3.12.1.4.2 Transmission Local Reliability*

Willamette Valley generators influence local power and transmission reliability in nearby communities. For example, in February of 2019, a severe winter storm caused an outage on the Hills Creek to Lookout Point 115kV line, which isolated the community of Oakridge from February 24 to March 5. Hills Creek generation was critical to providing this community with electric power while the line was repaired. It is expected that under current circumstances, Hills Creek would be needed most years to provide service to Oakridge in the event of a transmission outage. Also of note, in 2020, fires burned through the Thurston to Holden Creek 115kV transmission line, causing a multi-day outage. Cougar was able to generate while isolated ("islanded") from the main power system to provide power to the community of Blue Ridge. Alternatives that compromise the ability for generators at Hills Creek and Cougar to produce power can affect local power supply in those specific communities in such extreme events.

### 3.12.2 Environmental Consequences

This section evaluates effects of the Alternatives in comparison to the No Action Alternative on power generation, power system reliability, power flows across the transmission system, and economic viability of WVS projects power generation.

#### *3.12.2.1 Methodology*

##### *3.12.2.1.1 Area of Analysis*

The areas of analysis for the power and transmission resources are different from each other because of the nature of their services and products. Both the power and transmission analyses are focused on the Bonneville service area shown in Figure 3.12-3. Bonneville's service area is

[22] Congestion occurs on electric transmission systems when flows of electricity across a portion of the system are restricted or constrained below desired levels (DOE 2014).

defined by the Northwest Power Act as the Pacific Northwest, which includes Oregon, Washington, Idaho, the portion of Montana west of the Continental Divide, and the portions of Nevada, Utah, northern California, and Wyoming within the Columbia River drainage basin ("Bonneville's Service Area").[23] However, because Bonneville regularly markets its surplus power both within and outside the Pacific Northwest, the power analysis additionally considers potential effects on the power markets within the larger Western Interconnection area (Figure 3.12-4).

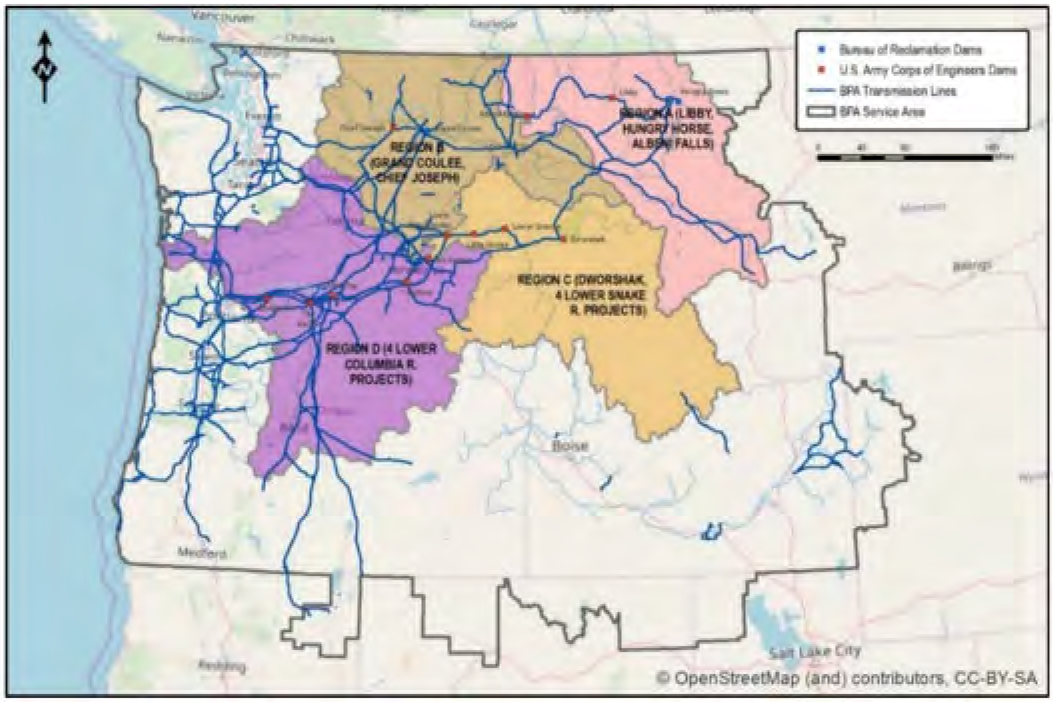



**Figure 3.12-3. Transmission Area of Analysis – the Bonneville Service Area.**

[23] 16 U.S.C. § 839a(14) (2018).


**Figure 3.12-4. Power Area of Analysis – the U.S. Portion of the Western Interconnection and the Bonneville Service Area.**

The future of power generation and transmission across the Pacific Northwest is subject to uncertainty, even under the No Action Alternative, due to evolving policy (e.g., emissions reductions targets), environmental factors (e.g., climate change) and technological growth. To evaluate the potential effects of the Action Alternatives against the No Action Alternative, the power generation and transmission analysis requires a common set of assumptions regarding these factors. These common assumptions, as identified throughout the methodology and results discussion, form the “base case” for the analysis.

### *3.12.2.1.2 Base Case Methodology*

This analysis assesses changes to power generation that would result from the Action Alternatives to inform Bonneville’s ability to assure an adequate and reliable supply of power to meet its firm power obligations under long-term contracts. The analysis considers whether the Action Alternatives require Bonneville or other regional entities (i.e., wholesale customers who might be receiving less power from Bonneville under an alternative) to acquire power from new resources (e.g., new or existing generating plants, wind, solar, etc.[24]) and/or construct new transmission infrastructure to replace lost capability at federal hydropower projects. To the extent that this confirms that this would indeed be the case, and if Bonneville proposes to take such action in the future, Bonneville would do so consistent with its applicable statutes (such as

[24] In the context of power acquired from new resources, “existing” refers to currently operating generating plants or renewables (e.g., wind, solar, etc.) located outside of the Pacific Northwest region.

the Northwest Power Act and Transmission System Act) and would complete additional site-specific planning, analysis, and compliance with environmental laws including NEPA.

The power and transmission analysis characterizes effects as beneficial or adverse (or no effect, where relevant), considering the following:

- Geographic scope of the effect or the size of the population affected. Because of the interconnected nature of the Pacific Northwest electricity system, changes at one or more WVS projects may affect power and transmission more broadly across the Pacific Northwest.
- Relative magnitude of the effect. The intensity of the power and transmission effects refers to the scale of changes in power generation; transmission flows; Net Present Value, and levelized cost of generation.
- How an effect persists over time. An effect may be moderate in the short term (e.g., limited to a construction period), but have negligible or no effect over the long term (e.g., beyond the construction period and within the analyses period). The power and transmission analyses considers the effects of the alternatives over a 30-year and 10-year timeframe, respectively.[25]

Figure 3.12-5 provides a high-level overview and depiction of the analytical framework. Note that multiple components of the analysis occur within each of the boxes depicted in the figure.

[25] Bonneville's standard power generation economic analysis timeframe is 50 years. For consistency with other analyses in the EIS, a 30-year timeframe was used instead. For transmission analysis, WECC produces power flow models for the Western Interconnect power system for different planning horizons and a 10-year case is the furthest case produced.

Additional methodological information is described further in the step descriptions below and in Appendix G, *Power Generation and Transmission*.

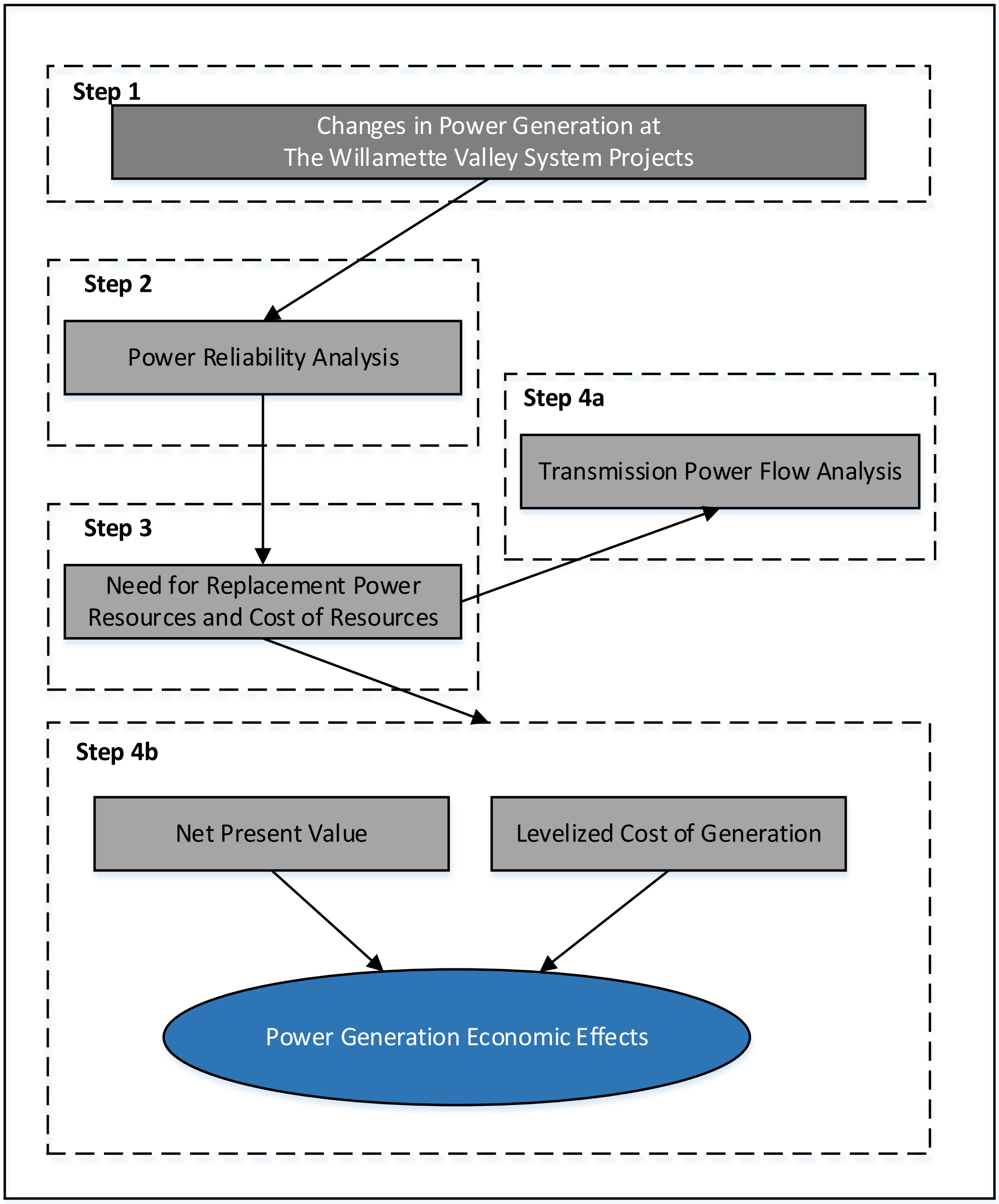



**Figure 3.12-5. Analytical Approach for Evaluating Power and Transmission Effects.**

Note*:* Additional power and transmission analysis occurs within each of the step boxes depicted.

Step 1 of the analysis assesses the effects of the Alternatives on hydropower generation based on average historical water conditions and for critical water conditions.[26] The Bonneville

[26] The "critical water year" or "critical water conditions" represent the historic water year (in this case, 1937) when the capability of the hydropower system produces the least amount of dependable generation to serve the least amount of load while considering power and non-power operating constraints. In June 2022, BPA

hydropower simulation model (HYDSIM) calculates power generation and analyzes that output in 73 different flow years (Water Years 1935/36 through 2007/08) at each of the eight WVS projects. The amount of power generated by the system under each of the alternatives, including the No Action Alternative, determines whether additional changes to, or investments in, the system may be required to maintain Bonneville's ability to supply adequate and reliable power (both energy and capacity) to its firm power customers under 20-year contracts.

Step 2 of the analysis considers whether the region has enough power capacity and energy to meet consumer demand (i.e., load). It evaluates the extent to which the alternatives, including the No Action Alternative, would result in the need for Bonneville or other regional entities to acquire power from other resources (e.g., new or existing generating plants) and construct new transmission infrastructure to replace the lost capability at federal hydropower projects. Synthesizing HYDSIM hydropower generation outputs with NW Council load-and-resource forecasts and power-import assumptions, the GENeration Evaluation SYStem (GENESYS) model simulates regional power generation and demand to determine power system reliability (i.e., LOLP). If an Alternative reduces power system reliability relative to the No Action Alternative, then the analysis continues to Step 3; otherwise, it progresses directly to Step 4a (transmission analysis) and 4b (Net Present Value and levelized costs of generation analyses).

To the extent that Step 2 identifies a potential need to acquire power from new resources or to build transmission infrastructure to meet load, Step 3 would identify potential replacement resources and associated costs[27].

Step 4a, the transmission analysis, estimates the incremental power flow change on Bonneville Network flow paths between the No Action Alternative and each of the other Alternatives during multiple seasons as a result of generation output changes at the Federal WVS projects with hydropower facilities (Detroit, Big Cliff, Cougar, Green Peter, Foster, Hills Creek, Lookout Point, and Dexter dams). The Bonneville transmission system analysis relies on power flow models to assess changes to the flow of electricity on the transmission system under each alternative. Because the transmission system is planned to reliably operate during times of peak loading, performance (and the need to reinforce the system to maintain reliable transmission operation) is analyzed during seasonal peak loading times within the region. Replacement resource assumptions (including quantities and general locations) developed under Step 3 were incorporated into the power flow models. Results of the generation and power flow models were used, along with individual WVS projects' transmission grid connections (single or more than one transmission line) and susceptibility of those connections

decided to update its long-term hydropower planning. BPA will only use the last-30-year subset of the most recent (1989 to 2018) flows and will take a statistical approach to establish firm generation. This methodology will first be used in the BP-24 rate case.

[27] If Bonneville proposes to take such action in the future, Bonneville would do so consistent with the Northwest Power Act and would complete additional site-specific planning and analysis in compliance with environmental laws, including the National Environmental Policy Act (NEPA).

to adverse weather/wildfire conditions, to qualitatively assess potential effects on local transmission reliability.

Step 4b of the analysis considers the Net Present Value (NPV) and Levelized Cost of Generation (LCOG) resulting from the increased costs of providing power associated with the inclusion of any new capital investments under each of the Alternatives. The NPV analysis compares the expected revenue produced by each WVS Project with hydropower facilities against their expected costs over a 30-year study period for each of the Alternatives. A positive NPV indicates that power generation is economically justified while a negative NPV indicates that the costs of power production outweigh the benefits. The LCOG analysis evaluates the incremental cost of producing power, in $/MWh, for each project over the 30-year study period. This value provides a relative measure of cost-competitiveness when compared to other generating resources or market purchases.

Direct effects to power and transmission caused by construction activities will not be analyzed as part of this EIS because these will be analyzed later as part of that proposed construction action's tiered NEPA analysis. During the planning process for any construction activity, the Corps would determine to what extent power and transmission may be impacted at that facility.

Additional details on the methodology used to analyze the effects of the Alternatives as well as the results of the analysis are contained in Appendix G, *Power and Transmission*.

Table 3.12-5 provides a summary of Power and Transmission effects for all WVS Programmatic Environmental Impact Statement (PEIS) Alternatives.

**Table 3.12-5. Summary of Power and Transmission Effects for All WVS PEIS Alternatives.**

| Alternative | Regional Power System Reliability Impacts | Replacement Resources Impacts | Transmission System Impacts | Economic Viability of Power Generation Impacts |
|---|---|---|---|---|
| No Action (NAA) | Same or similar to affected environment. WVS Projects 73-Year Average Generation is estimated to be 171 aMW28 (roughly the amount of power used by 136,416 Northwest homes or used by residential customers in a city slightly more populated than Gresham, Oregon). Loss of Load Probability (LOLP) is 6.5%, which is within the range of the Pacific Northwest Power System LOLP in recent years, and the risk of blackouts or power shortages is about once every 15 years. | ——[1] | Same or similar to affected environment. The congested paths of Cross Cascades South (CCS) and South of Allston (SOA) remain congested. Generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages due to, especially, weather events or fires. | Same or similar to affected environment. Power generation for combined WVS projects would continue to be marginally economically viable. Net Present Value for the combined WVS is about $225 million and the median Levelized Cost of Generation is estimated to be $26.70/MWh. |
| Alternative 1 | Negligible impact on power system reliability. Average annual hydropower generation from the WVS projects would increase by 8 aMW (roughly enough to power 6,371 households annually). LOLP only decreases by 0.1 percent | NA2 | Long-term, minor, adverse effects on the transmission system. Less than 10MW increased loading on congested paths all seasons (CCS and SOA). Generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated) similar to the NAA. Construction projects at Cougar Dam are not anticipated to impact local | Long-term, major, adverse effects on economic viability of power generation. There would be a $1.159 billion reduction in Net Present Value to -$934 million and a $27.14 increase in the Levelized Cost of Generation to $53.84/MWh. |

[28] An average megawatt is one million watts delivered continuously 24 hours a day for one year.

| Alternative | Regional Power System Reliability Impacts | Replacement Resources Impacts | Transmission System Impacts | Economic Viability of Power Generation Impacts |
|---|---|---|---|---|
| | and the risk of blackouts or power shortages remains the same resulting in no detectable change to regional power system reliability. | | transmission services to Blue River provided generation is not affected. | |
| Alternative 2A | Negligible impact on power system reliability. Average annual hydropower generation from the WVS projects would decrease by 4 aMW (roughly enough to power 3,185 households annually). LOLP and the risk of blackouts or power shortages remain the same as the NAA. | NA[2] | Long-term, moderate, adverse effects on the transmission system. Increased loading in winter on CCS path (18.4MW) and in spring on both CCS (61.3MW) and SOA (11.8MW) paths. Generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated), providing transmission services to Oakridge and Blue River, respectively, similar to the NAA. Construction projects at Cougar Dam are not anticipated to impact local transmission services to Blue River provided generation is not affected. | Long-term, major, adverse effects on economic viability of power generation. There would be a $863 million reduction in Net Present Value to -$638 million and a $20.75 increase in the Levelized Cost of Generation to $47.45/MWh. |
| Alternative 2B | Negligible impact on power system reliability. Average annual hydropower generation from the WVS projects would decrease by 18 aMW (roughly enough to power 14,334 households annually). LOLP only increases by 0.1 percent and the risk of blackouts or power shortages remains the same resulting in no | NA[2] | Long-term, moderate, adverse effects on the transmission system. Increased loading in winter on CCS path (21.9MW) and in spring on both CCS (25.1MW) and SOA (5.1MW) paths. Generation at Hills Creek Dam would remain able to operate islanded (isolated), providing transmission services to Oakridge, similar to the NAA. There would be adverse effects on transmission services to Blue River. Deep fall and spring drawdowns would compromise Cougar Dam's ability | Long-term, major, adverse effects on economic viability of power generation. There would be a $933 million reduction in Net Present Value to -$708 million and a $23.96 increase in the Levelized Cost of Generation to $50.66/MWh. |

| Alternative | Regional Power System Reliability Impacts | Replacement Resources Impacts | Transmission System Impacts | Economic Viability of Power Generation Impacts |
|---|---|---|---|---|
| | detectable change to regional power system reliability. | | to operate islanded and serve this community under temporary weather or fire related outage conditions. | |
| Alternative 3A | Negligible Impact on power system reliability. Hydropower generation from the WVS projects would decrease by 87 aMW (roughly enough to power 69,283 households annually). LOLP only increases by 0.5 percent and the risk of blackouts or power shortages remains the same resulting in no detectable change to regional power system reliability. | NA[2] | Long-term, moderate, adverse effects on the transmission system. Increased loading on CCS and SOA paths in winter (35.9MW and 13.6MW, respectively) and spring (113.7 MW and 22.3 MW, respectively). There would be adverse effects on transmission services to Oakridge and Blue River. Deep fall and spring drawdowns would compromise the Hills Creek and Cougar dams' respective abilities to operate islanded and serve these communities under temporary storm- or fire-related outage conditions. | Long-term, major, adverse effects on economic viability of power generation. There would be a $853 million reduction in Net Present Value to -$628 million and a $37.61 increase in the Levelized Cost of Generation to $64.32/MWh. |
| Alternative 3B | Negligible Impact on power system reliability. Hydropower generation from the WVS projects would decrease by 79 aMW (roughly enough to power 62,912 households annually). LOLP only decreases by 0.5 percent and the risk of blackouts or power shortages remains the same resulting in no detectable change to | NA2 | Long-term, moderate, adverse effects on the transmission system. Increased loading on CCS path all seasons (winter: 41.4MW, spring: 94.8 MW, and summer: 25.6MW) and on SOA path in winter (15.2MW) and spring (18.7 MW). There would be adverse effects on transmission services to Oakridge and Blue River. Deep fall and spring drawdowns would compromise the Hills Creek and Cougar dams' respective abilities to operate islanded and serve these communities | Long-term, major, adverse effects on economic viability of power generation. There would be a $829 million reduction in Net Present Value to -$604 million and a $32.72 increase in the Levelized Cost of Generation to $59.42/MWh. |

| Alternative | Regional Power System Reliability Impacts | Replacement Resources Impacts | Transmission System Impacts | Economic Viability of Power Generation Impacts |
|---|---|---|---|---|
| | regional power system reliability. | | under temporary weather or fire related outage conditions. | |
| Alternative 4 | Negligible impact on power system reliability. Average annual hydropower generation from the WVS projects would increase by 1 aMW (roughly enough to power 796 households annually). LOLP and the risk of blackouts or power shortages remain the same. | NA2 | Long-term, minor, adverse effects on the transmission system. Less than 10MW increased loading on congested paths (CCS and SOA) all seasons with exception of a slightly greater increase on the CCS path in spring (15MW). Generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated) similar to the NAA. Construction projects at Hills Creek and Cougar dams are not anticipated to impact local transmission services to Oakridge and Blue River, respectively, provided generation is not affected. | Long-term, major, adverse effects on economic viability of power generation. There would be a $1.162 billion reduction in Net Present Value to -$937 million and a $27.84 increase in the Levelized Cost of Generation to $54.54/MWh. |
| Alternative 5 | Negligible impact on power system reliability. Hydropower generation from the WVS projects would decrease by 18 aMW (roughly the amount of power consumed by 14,334 Northwest homes in a year) relative to the NAA on average under historical water conditions. The WVS projects would lose 12 aMW of firm power production under critical water conditions. LOLP would | NA2 | Alternative 5 was not studied independently of alternative 2B. Transmission impacts should be considered the same as alternative 2B. | Long-term, major, adverse effects on economic viability of power generation. There would be a $939 million reduction in Net Present Value to -$714 million and a $24.11 increase in the Levelized Cost of Generation to $50.81/MWh. |

| Alternative | Regional Power System Reliability Impacts | Replacement Resources Impacts | Transmission System Impacts | Economic Viability of Power Generation Impacts |
|---|---|---|---|---|
| | increase to 6.6 percent associated due to loss in generation and no replacement resources would occur | | | |
| Near term operations measure | Negligible impact on power system reliability. Average annual hydropower generation from the WVS projects would decrease by 52 aMW (roughly enough to power 41,392 households annually). LOLP and the risk of blackouts or power shortages remain the same. | NA2 | Long-term, moderate, adverse effects on the transmission system. Increased loading on CCS path in winter (47.0 MW) and spring (59.8 MW). Generation at Hills Creek would generally remain able to operate islanded (isolated) similar to the NAA, though some decrease in night time capability may occur. Deep fall and spring drawdowns would compromise Cougar Dam ability to operate islanded and serve the Blue River community under temporary weather or fire related outage conditions. | Long-term, major, adverse effects on economic viability of power generation. There would be a $421 million reduction in Net Present Value to -$196 million and a $11.65 increase in the Levelized Cost of Generation to $38.35/MWh. |

1/ A "——" indicates an effect category that is not relevant to the No Action Alternative because it only occurs as a result of implementing the Alternatives (e.g., the need for new generation and transmission infrastructure and associated costs).

2/ No replacement resources would occur; LOLP is within the reasonable historical range of the NW Council target.

3/ Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the Levelized Costs of Generation would be incrementally higher. Additionally, structural cost estimates used in the analysis were at a conceptual design level with a 50% contingency. For other projects of similar size and complexity, the conceptual design cost estimates increased by 137% to 215% upon completion of the detailed design report. Post-construction, the complexity of these systems has typically resulted in further costs to improve performance. Higher implementation costs than currently estimated would result in additional reductions of the Net Present Value and increases in the levelized costs of generation.

4/Near-term operations measure effects are only inclusive of near-term operational measures and do not account for structural measures that have been proposed under the court order (e.g., upgrades to the Dexter adult fish facility), nor do they account for operational changes that could occur as a result of structural measure implementation.

### 3.12.2.2 *No Action Alternative*

This section evaluates power and transmission effects under the No Action Alternative. "No Action" represents continued operations, configuration, and maintenance of the system under the operations rules in effect in 2019. The analysis below projects generation and reliability of the regional power system over a 30-year planning period. It accounts for planned maintenance at WVS projects in future years, load and resource forecasts, and planned retirements of coal power plants as of 2017 (i.e., base case assumptions).

#### *3.12.2.2.1 Power Generation*

Under the No Action Alternative, average annual generation for the combined WVS projects over a 73-year study period (Water Years 1935/36 through 2007/08) is estimated at 171 aMW and for the 1937 critical water year is 150 aMW (for reference, according to the NW Council, 1 aMW can power about 796 Northwest homes for a year). Table 3.12-6 presents the results of two hydropower-generation metrics that are useful for making comparisons between the No Action Alternative and the Action Alternatives. The first is average monthly generation for the WVS projects combined across a 73-year study period, which is greatest during the months of November through January and again in May corresponding to high winter/spring run-off and is lowest in the summer. The second is average generation for the WVS projects combined under a critical water year (1937), which is greatest during late April through June and lowest in December through February. Exhibit 2 in Appendix G provides detailed generation results by project and for all water years modeled.

**Table 3.12-6. WVS Projects 73-Year Average Generation (Water Years 1935/36 through 2007/08) and Critical Water Year (CWY, 1937) Average Generation (aMW): No Action Alternative.**[1]

| Month | No Action Alternative AVG GEN | No Action Alternative CWY GEN |
|---|---|---|
| October | 134 | 119 |
| November | 230 | 156 |
| December | 231 | 80 |
| January | 235 | 47 |
| February | 147 | 67 |
| March | 143 | 121 |
| April I | 177 | 188 |
| April II | 182 | 227 |
| May | 222 | 356 |
| June | 162 | 264 |
| July | 106 | 111 |
| August I | 114 | 115 |

| Month | No Action Alternative AVG GEN | No Action Alternative CWY GEN |
|---|---|---|
| August II | 118 | 124 |
| September | 151 | 155 |
| **Annual Average[2]** | **171** | **150** |

1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves. Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.

2/ The Annual Average is a weighted average to account for the different number of days in the 14 periods.

Source: HYDSIM modeling results.

##### *3.12.2.2.2 Power System Reliability*

Based on load forecasts, limited coal plant retirements, and changes in power generation, the No Action Alternative would result in an LOLP of 6.5 percent in 2022. This LOLP estimate relies on an assumption about the resources available to serve regional loads over time. The basis for that assumption is the NW Council's resource adequacy dataset developed in 2017. While it accounts for the planned coal plant closures known at that time, it also assumes coal plant generating capacity (4,246 MW) would continue to serve primarily regional IOU loads (Table 3.12.7). Although the No Action Alternative's LOLP exceeds the current NW Council target of five percent, the scope of the WVS EIS analysis does not address the resources that might be needed to achieve the NW Council target under the No Action Alternative.[29]

Energy economics and state and local de-carbonization policies are changing the generation portfolio in the region and across the Western Interconnection that will accelerate coal plant retirements post-2025. Since 2017, the year of the base-case assumptions used in this EIS, additional and accelerated coal plant retirements have been announced and more are being contemplated, mainly impacting the region's IOUs, which use these resources to serve their retail loads. In Washington, the Clean Energy Transformation Act (CETA) (2019) mandates the elimination of coal-generated electricity by all Washington utilities by 2025 (RCW 19.405). The Oregon Clean Energy and Coal Transition Act (2016) mandates the elimination of the cost of coal resources in retail rates of IOUs by 2030 (ORS 757.518). Additionally, deep reductions in greenhouse gas emissions are being mandated by recently enacted legislation, including Washington's CETA, Washington's Climate Commitment Act (2021, RCW 70A.65.260), and Oregon's clean energy standard (2021, HB 2021).

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[29] Note that LOLP is a probabilistic estimate and does not indicate magnitude or scale of potential power system outages and it is also not linear in effects; however, it is a useful metric of overall power system reliability and stability. Furthermore, the NW Council's target is not an enforceable standard (NW Council 2011). *See* NW Council 2011, Page 4, available at: https://www.nwcouncil.org/sites/default/files/2011_14_1.pdf ("The adequacy standard adopted by the NW Council does not mandate compliance or imply any enforcement mechanisms. It does not apply to individual utilities because each utility faces different circumstances. It is intended to be an early warning should aggregate regional resource development fall short, for whatever reason.").

The loss of dispatchable coal generation is having an impact on regional resource adequacy. According to E3 (March 2019), the retirement of coal power supplied to the Northwest threatens to create an electric power supply shortage of up to 8,000 MW by 2030 (E3 2019). In the Council's 8$^{th}$ Power Plan, they addressed regional reliability in the period from 2022 to 2029 that included additional coal plant retirements. Depending on the scenario, regional energy needs to meet the Council's adequacy standard range from 0 to 2,857 aMW. Regional utilities, including Bonneville, have begun working together to address the issue.

**Table 3.12-7. Coal Plants included/excluded in the No Action Alternative Genesys study and their generation capacities.**

| Coal Plant | State | MW |
|---|---|---|
| **Included** | | |
| Centralia 2 | WA | 670 |
| Colstrip 3 | MT | 518 |
| Colstrip 4 | MT | 681 |
| Hardin | MT | 119 |
| Jim Bridger 1 | WY | 530 |
| Jim Bridger 2 | WY | 530 |
| Jim Bridger 3 | WY | 530 |
| Jim Bridger 4 | WY | 530 |
| Montana 1 | MT | 4 |
| North Valmy 2 | NV | 134 |
| **Total Included** | | **4246** |
| **Excluded (Retired prior to 2022)** | | |
| Centralia 1 | WA | 670 |
| Boardman | OR | 570 |
| Valmy 1 | NV | 127 |
| Colstrip 1&2 | MT | 308 |
| Total Excluded | | **1675** |

#### *3.12.2.2.3 Potential Replacement Resources and Associated Costs*

Given the key assumptions described above for the base case analysis (including continued coal capacity), the analysis finds that no acquisition of power from new resources (i.e., replacement resources) would occur under the No Action Alternative. Though greater than the NW Council's standard of five percent, the 6.5 percent LOLP is within the reasonable historical range of the NW Council target.

#### *3.12.2.2.4 Transmission*

Under the No Action Alternative, no impacts to the transmission system would be expected. The congested paths of Cross Cascades South and South of Allston remain congested with capacity either a little unsubscribed or oversubscribed, respectively. For local impacts, generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages due primarily to weather events or fires.

Tables depicting power flows on Bonneville Transmission Network Paths under different seasonal conditions for all alternatives, including the No Action Alternative, are presented in Appendix G, Power and Transmission.

#### *3.12.2.2.5 Economic Viability of Power Generation*

Under the No Action Alternative, power generation from the combined WVS projects would remain marginally economically viable. As shown previously, the three-year (2018-2020) average cost of generation for the WVS projects under expected generation from the 2019 Bonneville White Book (Table 3.12-4) was $25.28/MWh. This cost of generation is currently marginal relative to average market prices and other generation resources and is among the highest costs in the FCRPS. Over the 30-year study period, the median Levelized Cost of Generation for the combined WVS projects is estimated to rise to $26.70/MWh under the No Action Alternative and the median Net Present Value is about $225 million[30]. Despite remaining economically viable, this indicates there is little room for taking on additional costs or operational changes without making WVS projects more costly to operate than their generation is worth.

Under the No Action Alternative, three individual projects[31] have positive median NPVs including Hills Creek ($39 million), Detroit/Big Cliff ($84 million), and Lookout Point/Dexter ($109 million). These same projects are the only ones with a positive Net Present Value in more than 50% of the 1,600 iterations. Levelized costs of individual projects range between $21.85/MWh (Hills Creek) and $33.86/MWh (Green Peter/Foster).

Tables depicting 30-year Net Present Value, Percent of Iterations with a Positive Net Present Value, and Levelized Cost of Generation for WVS projects are presented in Appendix G, *Power and Transmission*.

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[30] Bonneville's share of basin-wide costs (e.g., research, monitoring, and evaluation [RME]) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher.

[31] Cougar and Hills Creek dams are operated as individual projects. Additionally, peaking dams and their respective re-regulating dams are functionally operated together as individual projects; therefore, the combined peaking/reregulating dams (Detroit/Big Cliff, Green Peter/Foster, and Lookout Point/Dexter) are treated as individual projects.

### *3.12.2.2.6 Summary of Effects*

Table 3.12-8 presents generation, power system reliability, transmission flow paths and reliability, and economic conditions under the No Action Alternative, which would remain similar to recent history.

**Table 3.12-8. Summary of Conditions under the No Action Alternative.[5]**

| Metrics | No Action Alternative |
|---|---|
| WVS Projects 73-Year Average Generation (aMW) | 171 |
| WVS Projects Critical Water year (1937) Average Generation (aMW) | 150 |
| Loss of Load Probability (LOLP) | 6.5%[1] |
| Resource Replacement | ——[2] |
| Transmission Flow Paths[3]<br>Cross Cascades South | W 6475.5<br>SP 4100.5<br>SU 5862.9 |
| South of Allston | W 1183.0<br>SP 4100.5<br>SU 5862.9 |
| Transmission Reliability | Same or similar to affected environment[4] |
| Net Present Value (median) | $225 Million |
| Levelized Cost of Generation ($/MWh) | $26.70 |

1/ Though greater than the NW Council's standard of five percent, LOLP is within the reasonable historical range of the NW Council target.

2/ A "——" indicates an effect category that is not relevant to the No Action Alternative because it only occurs as a result of implementing the Alternatives (e.g., the need for new generation and transmission infrastructure and associated costs).

3/ The amount of loading (in MW) on the congested paths of Cross Cascades South (CCS) and South of Allston (SOA) are depicted during three seasonal cases (W= Winter Peak; SP= Spring Off-peak; SU= Summer Peak).

4/The congested paths of Cross Cascades South (CCS) and South of Allston (SOA) remain congested. Generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages due to, especially, weather events or fires.

5/Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher.

### *3.12.2.2.7 NAA Climate Change Impacts for Power Generation and Transmission*

Since the WVS will likely experience increasing winter time (December through March) flow volumes due to climate change generally, it is possible that projects may be able to capture some additional flow, which could produce incremental increases in power generation during the winter. However, higher projected air temperatures are likely to result in decreased heating loads. Increases in power generation that may occur in the winter months would incrementally decrease stress on existing congested transmission paths (i.e., South of Allston and Cross Cascades South).

Lower snowpack may reduce springtime and summertime flows, as well as potentially impact refill ability. This could lead to reduced ability to generate power in the spring and summer. Increasing air temperatures are likely to increase demand for power in the summer due to increased cooling loads. Decreases in power generation would incrementally increase stress on existing congested transmission paths (i.e., South of Allston and Cross Cascades South).

Decreasing summer and fall inflows may lead to more rapid drawdown in the fall to meet downstream minimum flow targets.

Reduced reservoir levels associated with decreased refill ability or drawdowns, combined with anticipated increases in the likelihood of extreme wildfire or weather events, would incrementally increase the risks that Cougar Dam would be unable to provide power during periods of reduced reservoir levels to the community of Blue River in the event a fire or severe weather event were to cause a transmission outage between Blue River and Thurston substations. Similarly, these conditions would incrementally increase the risks that Hills Creek Dam would be unable to provide power during periods of reduced reservoir levels to the community of Oakridge if a fire or weather event were to cause a transmission outage between Oakridge and Lookout Point Substation.

These potential climate change impacts to hydropower and transmission are based on the climate change impacts as described in the hydrologic processes section.

**All comparisons of effects for each action alternative are in comparison to the NAA unless stated otherwise.**

### *3.12.2.3 Alternative 1 – Project Storage Alternative*

#### *3.12.2.3.1 Changes in Power Generation*

Table 3.12-9 and Figure 3.12-6 present the generation results of the combined WVS projects for the No Action Alternative and Alternative 1 and differences by month. Overall, generation from the WVS projects would increase from 171 aMW under the No Action Alternative, on average, over all water years, to 179 aMW under Alternative 1. This represents an increase of 8 aMW, which is a 4.7 percent increase in average annual generation. The change in critical water year generation from 150 aMW under the No Action Alternative to 160 aMW under Alternative 1 represents a 10 aMW (or 6.7 percent) increase.

**Table 3.12-9. 73-Year Average Generation (Water Years 1935/36 through 2007/08) and Critical Water Year (CWY, 1937) Average Generation at the WVS Projects: Alternative 1 (ALT1) relative to No Action Alternative (NAA), in aMW.[1]**

| | AVG GEN NAA | AVG GEN ALT1 | AVG GEN Difference | CWY GEN NAA | CWY GEN ALT1 | CWY GEN Difference |
|---|---|---|---|---|---|---|
| Oct | 134 | 173 | 39 | 119 | 127 | 8 |
| Nov | 230 | 276 | 46 | 156 | 208 | 52 |
| Dec | 231 | 227 | -4 | 80 | 71 | -9 |
| Jan | 235 | 230 | -5 | 47 | 41 | -6 |
| Feb | 147 | 146 | -1 | 67 | 57 | -10 |
| Mar | 143 | 132 | -11 | 121 | 114 | -7 |
| Apr I | 177 | 150 | -27 | 188 | 185 | -3 |
| Apr II | 182 | 153 | -29 | 227 | 251 | 24 |
| May | 222 | 213 | -9 | 356 | 361 | 5 |
| Jun | 162 | 183 | 21 | 264 | 314 | 50 |
| Jul | 106 | 136 | 30 | 111 | 131 | 20 |
| Aug I | 114 | 134 | 20 | 115 | 132 | 17 |
| Aug II | 118 | 135 | 17 | 124 | 134 | 10 |
| Sep | 151 | 142 | -9 | 155 | 143 | -12 |
| **Annual Average[2]** | **171** | **179** | **8** | **150** | **160** | **10** |

1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

2/ The Annual Average is a weighted average to account for the different number of days in the 14 periods.

Source: HYDSIM modeling results.

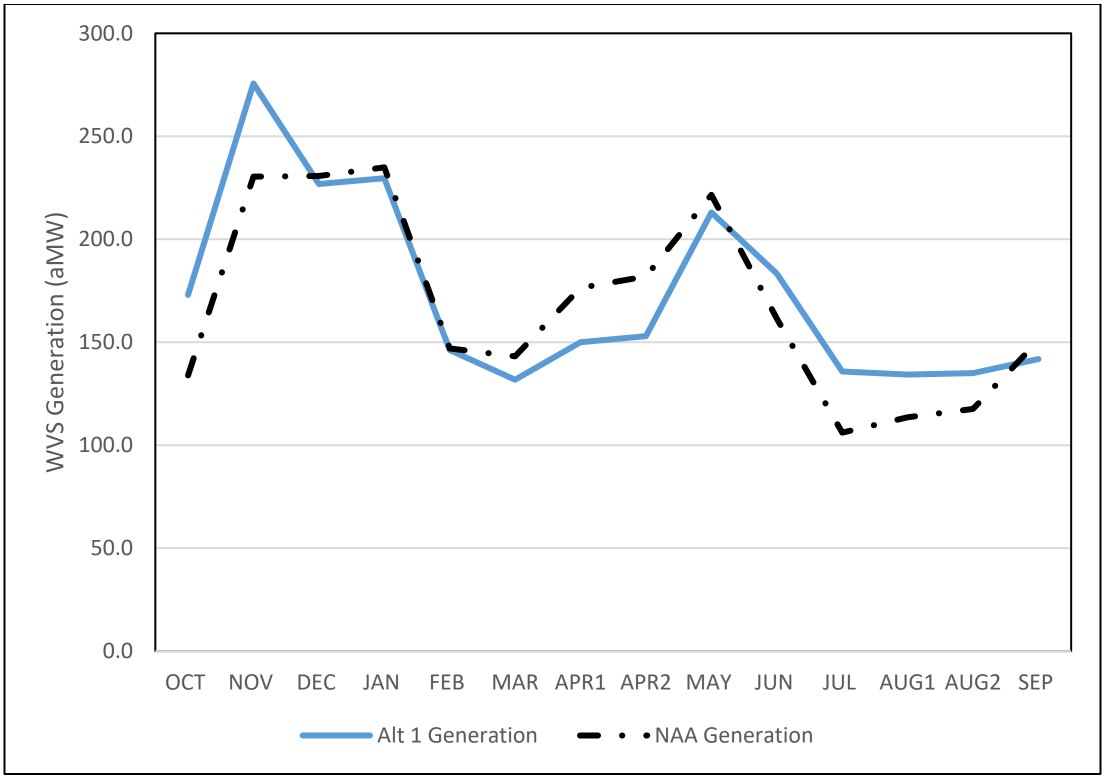


**Figure 3.12-6. Monthly Average Generation (aMW) at the WVS Projects, Alternative 1 and No Action Alternative.**

*3.12.2.3.2 Effects on Power System Reliability*

Due to the slight increase in total hydropower generation under Alternative 1, the LOLP would be 6.4 percent, or 0.1 percentage points lower than the LOLP in the No Action Alternative. The LOLP changes from the No Action Alternative (6.5 percent) to Alternative 1 (6.4 percent) are negligible (i.e., within the +/- 1 percent range of modeling accuracy). A 6.4 percent LOLP under Alternative 1 is roughly equivalent to a one-in-fifteen year likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions), which is the same likelihood of an event(s) as the No Action Alternative.

*3.12.2.3.3 Potential Replacement Resources and Associated Costs*

Given that the LOLP is not materially different between Alternative 1 and the No Action Alternative, the analysis finds that no acquisition of power from new resources (i.e., replacement resources) would be needed under Alternative 1 to return the LOLP to the No Action Alternative level. Though greater than the NW Council's standard of five percent, the 6.4 percent LOLP under Alternative 1 is within the reasonable historical range of the NW Council target.

#### *3.12.2.3.4 Effects on Transmission*

Overall, changes in the patterns of WVS projects generation under Alternative 1 would have minor impacts to the transmission system. The congested paths of Cross Cascades South and South of Allston would remain congested with small (less than 10MW) increases to loading expected. For local impacts, generation at Hills Creek and Cougar dams would continue to be able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages due primarily to weather events or fires. Construction projects at Cougar Dam are not anticipated to impact local transmission services to Blue River provided generation is not affected.

Tables depicting power flows on Bonneville Transmission Network Paths under different seasonal conditions for Alternative 1 with comparison to the No Action Alternative are presented in Appendix G, Power and Transmission.

#### *3.12.2.3.5 Effects on Economic Viability of Power Generation*

Under Alternative 1, power generation from the combined WVS projects would not be economically viable. Over the 30-year study period, power operations are estimated to have a median Net Present Value of -$934 million under Alternative 1[32]. This is a $1.159 billion, or 515 percent, reduction in Net Present Value compared to the No Action Alternative. Across the 1,600 iterations that varied energy prices and water conditions, only 0.7 percent resulted in a positive Net Present Value for the combined WVS projects. The median Levelized Cost of Generation for the combined WVS projects is estimated to rise from $26.70/MWh under the No Action Alternative to $53.84/MWh under Alternative 1, which is a $27.14, or 102 percent, increase. This is substantially greater than expected market prices and less competitive compared to other renewable resources that are expected to become more affordable in the future.

When considering projects individually, all of the WVS projects under Alternative 1, with the exception of Hills Creek, have negative median Net Present Values, ranging from -$22 million (Cougar) to -$351 million (Detroit/Big Cliff) and their levelized costs of generation range from $38.22/MWh (Cougar) to 66.01/MWh (Green Peter/Foster). Hills Creek was the only project with a positive Net Present Value at $45 million and a levelized cost of generation of $21.26/MWh. Across the 1600 iterations from the analysis, Cougar and Hills Creek resulted in a positive Net Present Value in 26% and 92% of the iterations, respectively. Detroit/Big Cliff,

[32] Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher. Additionally, structural cost estimates used in the analysis were at a conceptual design level with a 50% contingency. For other projects of similar size and complexity, the conceptual design cost estimates increased by 137% to 215% upon completion of the detailed design report. Post-construction, the complexity of these systems has typically resulted in further costs to improve performance. Higher implementation costs than currently estimated would result in additional reductions of the Net Present Value and increases in the levelized costs of generation.

Green Peter/Foster, and Lookout Point/Dexter had a positive NPV in less than 0.5% of the iterations.

Tables depicting 30-year Net Present Value, Percent of Iterations with a Positive Net Present Value, and Levelized Cost of Generation for WVS projects are presented in Appendix G, Power and Transmission.

### *3.12.2.3.6 Summary of Effects*

Table 3.12-10 presents generation, power system reliability, transmission flow paths and reliability, and economic conditions under the No Action Alternative with comparison to Alternative 1. Under Alternative 1, the average annual hydropower generation from the WVS projects would increase by 8 aMW (roughly the amount of power consumed by 6,371 Northwest homes in a year) relative to the No Action Alternative. The WVS projects would gain 10 aMW of firm power production under critical water conditions. Alternative 1 decreases the LOLP to 6.4 percent associated with the incremental gain in generation and no replacement resources would be needed to return the LOLP to the No Action Alternative level since this difference of 0.1 percent is within the +/-1 range of the accuracy of the model. The LOLP is within the reasonable historical range of the NW Council target. Therefore, impacts to power system reliability would be negligible.

Under Alternative 1, minor regional and no local transmission impacts are anticipated.

Under Alternative 1, power generation from the combined WVS projects would not be economically viable. There would be a $1,159 billion reduction in Net Present Value and a $27.14 increase in the median Levelized Cost of Generation compared to the No Action Alternative[14]. Under Alternative 1, long-term, major, adverse effects on economic viability of power generation are anticipated.

**Table 3.12-10. Summary of Effects under Alternative 1 (ALT 1).[5]**

| Metrics | No Action Alternative | ALT1 | ALT1 relative to No Action |
|---|---|---|---|
| WVS Projects 73-Year Average Generation (aMW) | 171 | 179 | +8 |
| WVS Projects Critical Water year (1937) Average Generation (aMW) | 150 | 160 | +10 |
| Loss of Load Probability (LOLP) | 6.5% | 6.4% | -0.1 |
| Resource Replacement to return LOLP to No Action Alternative level | ——[1] | NA[2] | NA[2] |
| Transmission Flow Paths[3]<br>Cross Cascades South | W 6475.5<br>SP 4100.5<br>SU 5862.9 | W 6478.7<br>SP 4105.7<br>SU 5836.6 | W +3.2<br>SP +5.2<br>SU -26.3 |
| South of Allston | W 1183.0<br>SP 732.1 | W 1184.2<br>SP 733.9 | W +1.2<br>SP +1.8 |

| Metrics | No Action Alternative | ALT1 | ALT1 relative to No Action |
|---|---|---|---|
| | SU 2525.1 | SU 2521.9 | SU -3.2 |
| Transmission Reliability | Same/similar to affected environment[4] | No change | No change |
| Net Present Value (median) | $225 Million | -$934 Million | -$1.159 Billion |
| Levelized Cost of Generation ($/MWh) | $26.70 | $53.84 | +$27.14 |

Note: The estimated LOLP effect, and resulting transmission and economic viability effects, rely on the best available information regarding planned coal plant retirements as of 2017.

1/ A "——" indicates an effect category that is not relevant to the No Action Alternative because it only has potential to occur as a result of implementing an Action Alternative (e.g., the need for new generation and transmission infrastructure and associated costs).

2/ No replacement resources would be needed to return the LOLP to the No Action Alternative level since this difference of 0.1 percent is within the +/-1 range of the accuracy of the model; LOLP is within the reasonable historical range of the NW Council target.

3/ The amount of loading (in MW) on the congested paths of Cross Cascades South (CCS) and South of Allston (SOA) are depicted during three seasonal cases (W= Winter Peak; SP= Spring Off-peak; SU= Summer Peak).

4/ The congested paths of Cross Cascades South (CCS) and South of Allston (SOA) remain congested. Generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages due to, especially, weather events or fires.

5/Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher. Additionally, structural cost estimates used in the analysis were at a conceptual design level with a 50% contingency. For other projects of similar size and complexity, the conceptual design cost estimates increased by 137% to 215% upon completion of the detailed design report. Post-construction, the complexity of these systems has typically resulted in further costs to improve performance. Higher implementation costs than currently estimated would result in additional reductions of the Net Present Value and increases in the levelized costs of generation.

#### *3.12.2.3.7 Alternative 1 Climate Change Impacts for Power Generation and Transmission*

Since the WVS will likely experience increasing winter time (December through March) flow volumes due to climate change generally, it is possible that projects may be able to capture some additional flow which could produce incremental increases in power generation during the winter. However, higher projected air temperatures are likely to result in decreased heating loads. Increases in power generation would incrementally decrease stress on existing congested paths (i.e., South of Allston and Cross Cascades South).

Lower snowpack may reduce springtime and summertime flows, as well as potentially impact refill ability. This could lead to reduced ability to generate power in the spring and summer. Increasing air temperatures are likely to increase demand for power in the summer due to increased cooling loads. Decreases in power generation would incrementally increase stress on existing congested paths (i.e., South of Allston and Cross Cascades South).

Since flow targets are lower under Alternative 1, reservoirs could store more water during conservation season than under the No Action Alternative. However, it is likely this stored water would be needed to meet downstream flow targets due to climate change projected increased variability in the spring, drier, hotter summer months and lower summer base flow. Due to these changes under climate change and the downstream flow requirements under this alternative, reservoirs are projected to have lower water surface elevations compared to the No Action Alternative which would negatively impact power generation. Decreases in power generation would incrementally increase stress on existing congested paths (i.e., South of Allston and Cross Cascades South).

Reduced reservoir levels associated with decreased refill ability or drawdowns, combined with anticipated increases in the likelihood of extreme wildfire or weather events, would incrementally increase the risks that Cougar Dam would be unable to provide power during periods of reduced reservoir levels to the community of Blue River in the event a fire or severe weather event were to cause a transmission outage between Blue River and Thurston substations. Similarly, these conditions would incrementally increase the risks that Hills Creek Dam would be unable to provide power during periods of reduced reservoir levels to the community of Oakridge if a fire or weather event were to cause a transmission outage between Oakridge and Lookout Point Substation. These risks would be greater than the No Action Alternative and would be commensurate with the duration and timing of reduced reservoir levels.

These potential climate change impacts to hydropower are based on the climate change impacts as described in the hydrologic processes section.

##### *3.12.2.5.8 Evaluation of Near-Term Operations Measure*

Please refer to Chapter 2 for descriptions of the Near-Term Operations Measures. The Near-Term Operations Measure cannot occur under Alternative 1, but is detailed under Alternative 2A.

### 3.12.2.4 ***Alternative 2A -- Hybrid Alternative***

##### *3.12.2.4.1 Changes in Power Generation*

Table 3.12-11 and Figure 3.12-8 present the generation results of the combined WVS projects for the No Action Alternative and Alternative 2A and differences by month. Overall, generation from the WVS projects would decrease from 171 aMW under the No Action Alternative, on average, over all water years, to 167 aMW under Alternative 2A. This represents a decrease of 4 aMW, which is a 2.3 percent decrease in annual average generation. There was no difference in generation between the No Action Alternative and the critical water year.

**Table 3.12-11. 73-Year Average Generation (Water Years 1935/36 through 2007/08) and Critical Water Year (CWY, 1937) Average Generation at the WVS Projects: Alternative 2A (ALT2A) relative to No Action Alternative (NAA), in aMW.[1]**

| | AVG GEN NAA | AVG GEN ALT2A | AVG GEN Difference | CWY GEN NAA | CWY GEN ALT2A | CWY GEN Difference |
|---|---|---|---|---|---|---|
| Oct | 134 | 172 | 38 | 119 | 136 | 17 |
| Nov | 230 | 217 | -13 | 156 | 163 | 7 |
| Dec | 231 | 178 | -53 | 80 | 64 | -16 |
| Jan | 235 | 205 | -30 | 47 | 39 | -8 |
| Feb | 147 | 140 | -7 | 67 | 57 | -10 |
| Mar | 143 | 131 | -12 | 121 | 78 | -43 |
| Apr I | 177 | 151 | -26 | 188 | 182 | -6 |
| Apr II | 182 | 146 | -36 | 227 | 227 | 0 |
| May | 222 | 201 | -21 | 356 | 330 | -26 |
| Jun | 162 | 189 | 27 | 264 | 291 | 27 |
| Jul | 106 | 126 | 20 | 111 | 136 | 25 |
| Aug I | 114 | 128 | 14 | 115 | 122 | 7 |
| Aug II | 118 | 130 | 12 | 124 | 129 | 5 |
| Sep | 151 | 166 | 15 | 155 | 177 | 22 |
| **Annual Average[2]** | **171** | 167 | -4 | **150** | **150** | **0** |

1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

2/ The Annual Average is a weighted average to account for the different number of days in the 14 periods.

Source: HYDSIM modeling results.

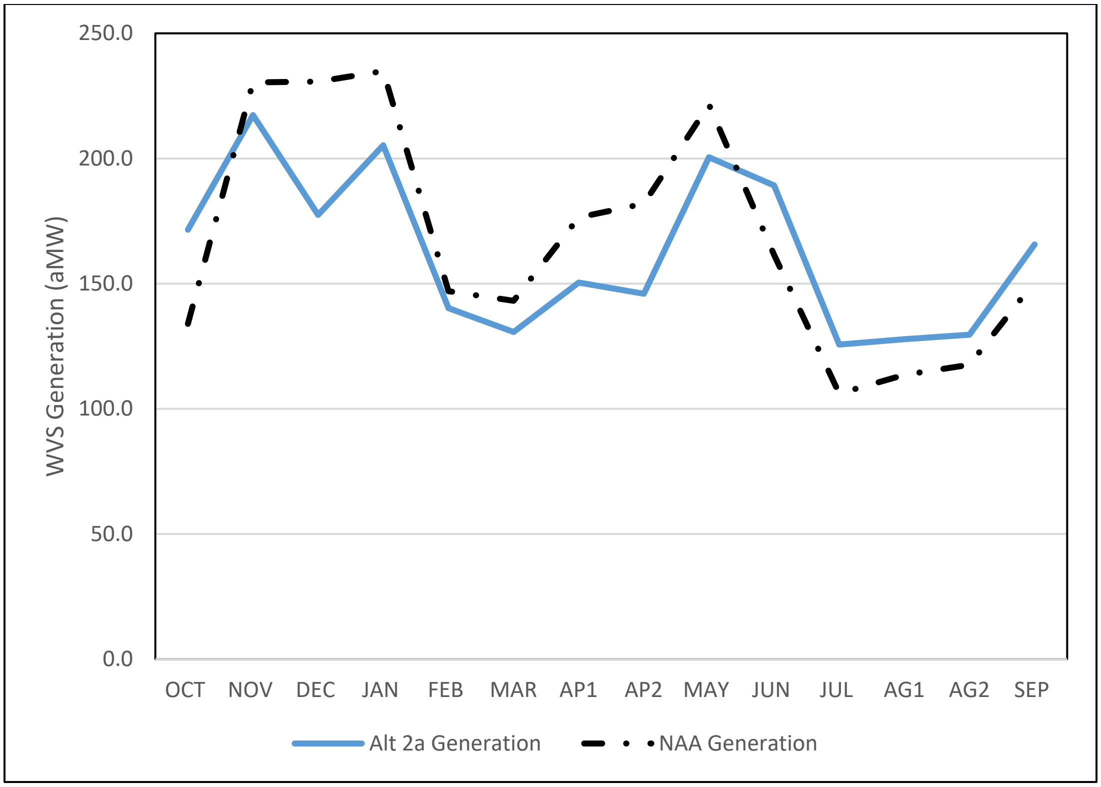


**Figure 3.12-7. Monthly Average Generation (aMW) at the WVS Projects, Alternative 2A and No Action Alternative.**

*3.12.2.4.2 Effects on Power System Reliability*

Due to the minimal decrease in total hydropower generation under Alternative 1, the LOLP would be 6.5 percent, which is the same as the No Action Alternative. A 6.5 percent LOLP is roughly equivalent to a one-in-fifteen year likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions).

*3.12.2.4.3 Potential Replacement Resources and Associated Costs*

Given that the LOLP is not materially different between Alternative 2A and the No Action Alternative, the analysis finds that no replacement resources would occur under Alternative 2A to return the LOLP to the No Action Alternative level. Though greater than the NW Council's standard of five percent, the 6.5 percent LOLP under Alternative 2A is within the reasonable historical range of the NW Council target.

*3.12.2.4.4 Effects on Transmission*

Overall, changes in the patterns of WVS projects generation under Alternative 2A would have moderate impacts to the transmission system due to the need to replace generation from more distant sources. Studies showed the congested path of Cross Cascades South increased 18.4MW in the Winter Peak case. Also, studies showed the congested paths of Cross Cascades South and South of Allston increased 61.3MW and 11.8MW in the Spring Off-peak case, respectively. For local impacts, generation at Hills Creek and Cougar dams would continue to be able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages due primarily to weather events or fires. Construction projects at Cougar Dam are not anticipated to impact local transmission services to Blue River provided generation is not affected.

Tables depicting power flows on Bonneville Transmission Network Paths under different seasonal conditions for Alternative 2A with comparison to the No Action Alternative are presented in Appendix G, Power and Transmission.

### *3.12.2.4.5 Effects on Economic Viability of Power Generation*

Under Alternative 2A, power generation from the combined WVS projects would not be economically viable. Over the 30-year study period, power operations are estimated to have a median Net Present Value of -$638 million under Alternative 2A[33]. This is a $863 million, or 384 percent, reduction in Net Present Value compared to the No Action Alternative. Across the 1,600 iterations that varied energy prices and water conditions, only 3.0 percent resulted in a positive Net Present Value. The median Levelized Cost of Generation for the combined WVS projects is estimated to rise from $26.70/MWh under the No Action Alternative to $47.45/MWh under Alternative 2A, which is a $20.75, or 78 percent, increase. This is substantially greater than expected market prices and less competitive compared to other renewable resources that are expected to become more affordable in the future.

Looking at individual projects[34], Hills Creek is the only WVS project that has a positive median Net Present Value at $43 million under Alternative 2A. It's levelized cost of generation is $21.54/MWh. Hills Creek is the only project that has a positive Net Present Value in more than 50% of the 1600 iterations from the economic analysis. Other projects have negative median Net Present Values ranging from -$28 million (Lookout Point/Dexter) to -$353 million (Detroit/Big Cliff); levelized costs of generation ranging from $34.52/MWh (Lookout Point/Dexter) to $64.74/MWh (Green Peter/Foster); and a proportion of 1,600 iterations resulting in a positive Net Present Value ranging from 0.1 percent (Green Peter/Foster) to 38.81 percent (Lookout Point/Dexter).

[33] Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher. Additionally, structural cost estimates used in the analysis were at a conceptual design level with a 50% contingency. For other projects of similar size and complexity, the conceptual design cost estimates increased by 137% to 215% upon completion of the detailed design report. Post-construction, the complexity of these systems has typically resulted in further costs to improve performance. Higher implementation costs than currently estimated would result in additional reductions of the Net Present Value and increases in the levelized costs of generation.

[34] Cougar and Hills Creek dams are operated as individual projects. Additionally, peaking dams and their respective re-regulating dams are functionally operated together as individual projects; therefore, the combined peaking/reregulating dams (Detroit/Big Cliff, Green Peter/Foster, and Lookout Point/Dexter) are treated as individual projects.

Tables depicting 30-year Net Present Value, Percent of Iterations with a Positive Net Present Value, and Levelized Cost of Generation for WVS projects are presented in Appendix G, Power and Transmission.

#### *3.12.2.4.6 Summary of Effects*

Table 3.12-12 presents generation, power system reliability, transmission flow paths and reliability, and economic conditions under the No Action Alternative with comparison to Alternative 2A. Under Alternative 2A, the average annual hydropower generation from the WVS projects would decrease by 4 aMW (roughly the amount of power consumed by 3,185 Northwest homes in a year) relative to the No Action Alternative. There would be no change in the firm power production of the WVS projects under critical water conditions.

There is no change in the LOLP under this alternative and no replacement resources would occur. The LOLP of 6.5 percent is within the reasonable historical range of the NW Council target. Therefore, impacts to power system reliability would be negligible.

Under Alternative 2A, a long-term, moderate impact on Cross Cascades South path and no local transmission impacts are anticipated.

Under Alternative 2A, power generation from the combined WVS projects would not be economically viable. There would be a $863 million reduction in Net Present Value and a $20.75 MWh increase in the median Levelized Cost of Generation compared to the No Action Alternative[16]. Under Alternative 2A, long-term, major, adverse effects on economic viability of power generation are anticipated.

**Table 3.12-12. Summary of Effects under Alternative 2A (ALT2A).[5]**

| Metrics | No Action Alternative | ALT2A | ALT2A relative to No Action |
|---|---|---|---|
| WVS Projects 73-Year Average Generation (aMW) | 171 | 167 | -4 |
| WVS Projects Critical Water year (1937) Average Generation (aMW) | 150 | 150 | 0 |
| Loss of Load Probability (LOLP) | 6.5% | 6.5% | 0 |
| Resource Replacement | ——[1] | N/A[2] | N/A[2] |
| Transmission Flow Paths[3]<br>Cross Cascades South | W 6475.5<br>SP 4100.5<br>SU 5862.9 | W 6493.9<br>SP 4161.8<br>SU 5853.5 | W +18.4<br>SP +61.3<br>SU -9.4 |
| South of Allston | W 1183.0<br>SP 732.1<br>SU 2525.1 | W 1189.9<br>SP 743.9<br>SU 2521.9 | W +6.9<br>SP +11.8<br>SU -9.0 |
| Transmission Reliability | Same/similar to affected environment[4] | No change | No change |

| Metrics | No Action Alternative | ALT2A | ALT2A relative to No Action |
|---|---|---|---|
| Net Present Value (median) | $225 Million | -$638 million | -$863 million |
| Levelized Cost of Generation ($/MWh) | $26.70 | $47.45 | +$20.75 |

Note: The estimated LOLP effect, and resulting transmission and economic viability effects, rely on the best available information regarding planned coal plant retirements as of 2017.

1/ A "——" indicates an effect category that is not relevant to the No Action Alternative because it only has potential to occur as a result of implementing an Action Alternative (e.g., the need for new generation and transmission infrastructure and associated costs).

2/ No replacement resources would be needed to return the LOLP to the No Action Alternative level since this difference of 0.1 percent is within the +/-1 range of the accuracy of the model; LOLP is within the reasonable historical range of the NW Council target.

3/ The amount of loading (in MW) on the congested paths of Cross Cascades South (CCS) and South of Allston (SOA) are depicted during three seasonal cases (W= Winter Peak; SP= Spring Off-peak; SU= Summer Peak).

4/ The congested paths of Cross Cascades South (CCS) and South of Allston (SOA) remain congested. Generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages due to, especially, weather events or fires.

5/Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher. Additionally, structural cost estimates used in the analysis were at a conceptual design level with a 50% contingency. For other projects of similar size and complexity, the conceptual design cost estimates increased by 137% to 215% upon completion of the detailed design report. Post-construction, the complexity of these systems has typically resulted in further costs to improve performance. Higher implementation costs than currently estimated would result in additional reductions of the Net Present Value and increases in the levelized costs of generation.

##### *3.12.2.4.7 Alternative 2A Climate Change Impacts for Power Generation and Transmission*

Since the WVS will likely experience increasing winter time (December through March) flow volumes due to climate change generally, it is possible that projects may be able to capture some additional flow which could produce incremental increases in power generation during the winter. However, higher projected air temperatures are likely to result in decreased heating loads. Increases in power generation would incrementally decrease stress on existing congested paths (i.e., South of Allston and Cross Cascades South).

Lower snowpack may reduce springtime and summertime flows, as well as potentially impact refill ability. This could lead to reduced ability to generate power in the spring and summer. Increasing air temperatures are likely to increase demand for power in the summer due to increased cooling loads. Decreases in power generation would incrementally increase stress on existing congested paths (i.e., South of Allston and Cross Cascades South).

Climate change would affect Alternative 2A similar to the No Action Alternative with regards to hydropower. Under Alternative 2A, there may be the potential to release and store more water in the spring and summer of dry years as compared to the No Action Alternative. The flow targets in Alternative 2A are lower than the current flow requirements, the reservoir may be able to store more water. However, the projects would likely have to use more of the stored water later in the season due to the projected variability in the spring months, hotter, drier summers, and lower summer base flow due to climate change.

Reservoirs in Alternative 2A sometimes drop to minimum elevation during the summer, but less often than the No Action Alternative, meaning storage levels would generally be able to augment summer flow for longer than the No Action Alternative even with projected decline in later spring and summer flows. This may alleviate some of the projected in decrease in power generation in the summer from climate change than would occur under the No Action Alternative.

Reduced reservoir levels associated with decreased refill ability or drawdowns, combined with anticipated increases in the likelihood of extreme wildfire or weather events, would incrementally increase the risks that Cougar Dam would be unable to provide power during periods of reduced reservoir levels to the community of Blue River in the event a fire or severe weather event were to cause a transmission outage between Blue River and Thurston substations. Similarly, these conditions would incrementally increase the risks that Hills Creek Dam would be unable to provide power during periods of reduced reservoir levels to the community of Oakridge if a fire or weather event were to cause a transmission outage between Oakridge and Lookout Point Substation. These risks would be greater than the No Action Alternative, commensurate with the duration and timing of reduced reservoir levels.

These potential climate change impacts to hydropower are based on the climate change impacts as described in the hydrologic processes section.

##### *3.12.2.4.8 Evaluation of Near Term Operations Measure*

See Alternative 2A, Section 3.12.2.3.8, for description of effects due to the Near-Term Operations Measure.

##### *3.12.2.4.9 Changes in Power Generation*

Table 3.12-13 and Figure 3.12-7 present the generation results of the combined WVS projects for the No Action Alternative and the Near-term operations measure in differences by month. Overall, generation from the WVS projects would decrease from 171 aMW under the No Action Alternative, on average, over all water years, to 120 aMW under Near-term operations measure. This represents a decrease of approximately 52 aMW, which is a 30.1 percent decrease in average annual generation. The change in critical water year generation from 150 aMW under the No Action Alternative to 108 aMW under Near-term operations measure represents a 42 aMW (or 28 percent) decrease.

**Table 3.12-13. 73-Year Average Generation (Water Years 1935/36 through 2007/08) and Critical Water Year (CWY, 1937) Average Generation at the WVS Projects: Near term operations measure (NTOM) relative to No Action Alternative (NAA), in aMW.[1]**

| | AVG GEN NAA | AVG GEN NTOM | AVG GEN Difference | CWY GEN NAA | CWY GEN NTOM | CWY GEN Difference |
|---|---|---|---|---|---|---|
| Oct | 134 | 129 | -5 | 119 | 108 | -11 |
| Nov | 230 | 112 | -118 | 156 | 74 | -82 |
| Dec | 231 | 107 | -124 | 80 | 35 | -45 |
| Jan | 235 | 159 | -76 | 47 | 20 | -27 |
| Feb | 147 | 127 | -20 | 67 | 27 | -40 |
| Mar | 143 | 100 | -43 | 121 | 78 | -43 |
| Apr I | 177 | 81 | -96 | 188 | 106 | -82 |
| Apr II | 182 | 72 | -110 | 227 | 87 | -140 |
| May | 222 | 133 | -89 | 356 | 211 | -145 |
| Jun | 162 | 152 | -10 | 264 | 250 | -14 |
| Jul | 106 | 111 | 5 | 111 | 131 | 20 |
| Aug I | 114 | 98 | -16 | 115 | 107 | -8 |
| Aug II | 118 | 100 | -18 | 124 | 102 | -22 |
| Sep | 151 | 132 | -19 | 155 | 159 | 4 |
| **Annual Average[2]** | **171** | 120 | -52 | 150 | 108 | -42 |

1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

2/ The Annual Average is a weighted average to account for the different number of days in the 14 periods.

Source: HYDSIM modeling results.

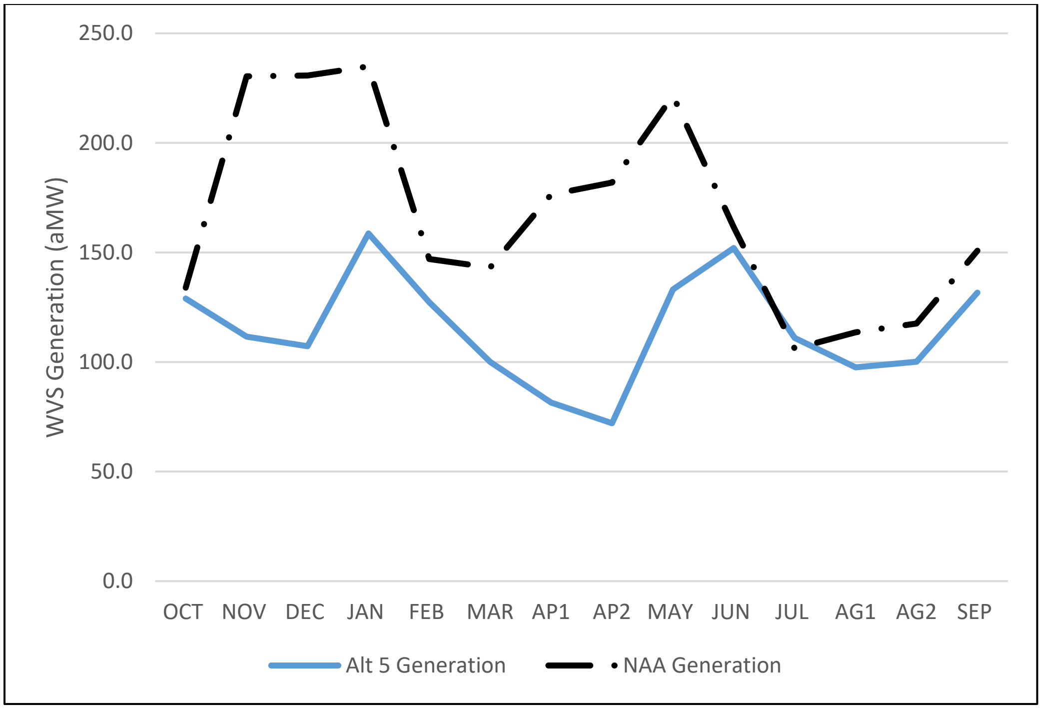


**Figure 3.12-8. Monthly Average Generation (aMW) at the WVS Projects, Near term operations measure and No Action Alternative.**

*3.12.2.4.10 Effects on Power System Reliability*

Due to the decrease in total hydropower generation under Near-term operations measure, the LOLP would be 6.8 percent, or 0.3 percentage points greater than the LOLP in the No Action Alternative. The LOLP change from the No Action Alternative (6.5 percent) to Near term operations measure (6.8 percent) is negligible (i.e., within the +/- 1 percent range of modeling accuracy). A 6.8 percent LOLP is roughly equivalent to a one-in-fifteen year likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions), which is the same likelihood of an event(s) as the No Action Alternative.

*3.12.2.4.11 Potential Replacement Resources and Associated Costs*

Given that the LOLP is not materially different between Near-term operations measure and the No Action Alternative, the analysis finds that no replacement resources would occur under Near term operations measure to return the LOLP to the No Action Alternative level. Though greater than the NW Council's standard of five percent, the 6.8 percent LOLP under Near-term operations measure is within the reasonable historical range of the NW Council target.

*3.12.2.4.12 Effects on Transmission*

Overall, changes in the patterns of WVS projects' generation under Near-term operations measure would have moderate impacts to the transmission system due to the need to replace generation from more distant sources. Studies showed that impacts to the congested paths of Cross Cascades South and South of Allston remain congested with significant (up to 60MW) increases to loading expected, especially in the Spring Off-peak case. For local impacts, generation at Hills Creek would generally continue to be able to operate islanded (isolated) from the rest of the power system, providing power to the community of Oakridge during power system outages primarily due to weather events or fires, though some decrease in capability during night time is anticipated. Deep fall and spring drawdowns of the Cougar reservoir would likely compromise the ability of Cougar Dam to provide power to the community of Blue River in the event of a fire or severe storm causing a transmission outage between Blue River and Thurston substations.

Tables depicting power flows on Bonneville Transmission Network Paths under different seasonal conditions for Near term operations measure with comparison to the No Action Alternative are presented in Appendix G, Power and Transmission.

#### *3.12.2.4.13 Effects on Economic Viability of Power Generation*

Under the Near-term operations measure, power generation from the combined WVS projects would not be economically viable. Over the 30-year study period, power operations are estimated to have a median Net Present Value of -$196 million under Near term operations measure[35]. This is a $421 million, or 187 percent, reduction in Net Present Value compared to the No Action Alternative. Across the 1,600 iterations that varied energy prices and water conditions, only 20.9 percent resulted in a positive Net Present Value. The median Levelized Cost of Generation for the combined WVS projects is estimated to rise from $26.70/MWh under the No Action Alternative to $38.35/MWh under Near term operations measure, which is an $11.65, or 44 percent, increase. This is greater than expected market prices and less competitive compared to other renewable resources that are expected to become more affordable in the future.

Looking at individual projects[36], Detroit/Big Cliff and Hills Creek are the only WVS projects having positive median Net Present Values of $5 million and $49 million, respectively; and their levelized costs of generation are $31.97/MWh and $21.57/MWh, respectively. They are also the only projects having a positive Net Present Value in more than 50% of the iterations. Other projects have negative median Net Present Values ranging from -$32 million (Cougar) to -$123 million (Green Peter/Foster) and levelized costs of generation ranging from $42.76/MWh (Cougar) to $50.40/MWh (Green Peter/Foster); and a proportion of 1,600 iterations resulting in

[35] Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher. Additionally, Near term operations measure effects are only inclusive of near term operational measures and do not account for structural measures that have been proposed under the court order (e.g., upgrades to the Dexter adult fish facility), nor do they account for operational changes that could occur as a result of structural measure implementation.

[36] Cougar and Hills Creek dams are operated as individual projects. Additionally, peaking dams and their respective re-regulating dams are functionally operated together as individual projects; therefore, the combined peaking/reregulating dams (Detroit/Big Cliff, Green Peter/Foster, and Lookout Point/Dexter) are treated as individual projects.

a positive Net Present Value ranging from 1.4 percent (Green Peter/Foster) to 14.4 percent (Cougar).

Tables depicting 30-year Net Present Value, Percent of Iterations with a Positive Net Present Value, and Levelized Cost of Generation for WVS projects are presented in Appendix G, *Power and Transmission*.

#### *3.12.2.4.14 Summary of Effects*

Table 3.12-14 presents generation, power system reliability, transmission flow paths and reliability, and economic conditions under the No Action Alternative with comparison to Near term operations measure. Under Near term operations measure, annual average hydropower generation from the WVS projects would decrease by 52 aMW (roughly the amount of power consumed by 41,392 Northwest homes in a year) relative to the No Action Alternative. The WVS projects would lose 42 aMW of firm power production under critical water conditions. Near term operations measure increases the LOLP to 6.8 percent associated with the loss in generation and no replacement resources would occur since this 0.3 percent difference relative to the No Action Alternative is within the +/-1 range of the accuracy of the model. The LOLP is within the reasonable historical range of the NW Council target. Therefore, impacts to power system reliability would be negligible.

A moderate impact on the Cross Cascades South transmission path would be expected. Overall, the ability for Hills Creek and Cougar generation to support the communities of Oakridge and Blue River, respectively, during temporary transmission outages would continue to be available similar to the No Action Alternative, though some decrease in capability is anticipated.

Under Near term operations measure, power generation from the combined WVS projects would not be economically viable. There would be a $421 million reduction in Net Present Value and a $11.65/MWh increase in the median Levelized Cost of Generation compared to the No Action Alternative.[27] Under Near term operations measure, long-term, major, adverse effects on economic viability of power generation are anticipated.

**Table 3.12-14. Summary of Effects under Near term operations measure (NTOM).** [1]

| Metrics | No Action Alternative | NTOM | NTOM relative to No Action |
|---|---|---|---|
| WVS Projects 73-Year Average Generation (aMW) | 171 | 120 | -52 |
| WVS Projects Critical Water Year (1937) Average Generation (aMW) | 150 | 108 | -42 |
| Loss of Load Probability (LOLP) | 6.5% | 6.8% | +0.3 |
| Resource Replacement | ——[2] | N/A[3] | N/A[3] |
| Transmission Flow Paths[4]<br>Cross Cascades South | W 6475.5<br>SP 4100.5<br>SU 5862.9 | W 6522.5<br>SP 4160.3<br>SU 5872.1 | W +47.0<br>SP +59.8<br>SU +9.2 |

| Metrics | No Action Alternative | NTOM | NTOM relative to No Action |
|---|---|---|---|
| South of Allston | W 1183.0<br>SP 732.1<br>SU 2525.1 | W 1200.0<br>SP 743.5<br>SU 2528.7 | W +17.0<br>SP +11.4<br>SU +3.6 |
| Transmission Reliability | Same/similar to affected environment[5] | Regionally- Same/similar to NAA<br>Locally: Generally same/similar to NAA, some decreased capability | No change regionally; minimal local change, some decreased capability to operate islanded at Hills Creek and Cougar dams during deep fall and spring drawdowns under certain conditions |
| Net Present Value (median) | $225 Million | -$196 million | -$421 million |
| Levelized Cost of Generation ($/MWh) | $26.70 | $38.35 | +$11.65 |

Note: The estimated LOLP effect, and resulting transmission and economic viability effects, rely on the best available information regarding planned coal plant retirements as of 2017.

1/ Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher. Additionally, Near term operations measure effects are only inclusive of near term operational measures and do not account for structural measures that have been proposed under the court order (e.g., upgrades to the Dexter adult fish facility), nor do they account for operational changes that could occur as a result of structural measure implementation.

2/ A "——" indicates an effect category that is not relevant to the No Action Alternative because it only has potential to occur as a result of implementing an Action Alternative (e.g., the need for new generation and transmission infrastructure and associated costs).

3/ No replacement resources would be needed to return the LOLP to the No Action Alternative level since this difference of 0.1 percent is within the +/-1 range of the accuracy of the model; LOLP is within the reasonable historical range of the NW Council target.

4/ The amount of loading (in MW) on the congested paths of Cross Cascades South (CCS) and South of Allston (SOA) are depicted during three seasonal cases (W= Winter Peak; SP= Spring Off-peak; SU= Summer Peak).

5/ The congested paths of Cross Cascades South (CCS) and South of Allston (SOA) remain congested. Generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages due to, especially, weather events or fires.

#### *3.12.2.4.15 Near term operations measure Climate Change Impacts for Power Generation and Transmission*

Since the WVS will likely experience increasing winter time (December through March) flow volumes due to climate change generally, it is possible that projects may be able to capture some additional flow and produce incremental increases in power generation during the winter. However, higher projected temperatures are likely to result in decreased heating loads.

Increases in power generation would incrementally decrease stress on existing congested paths (i.e., South of Allston and Cross Cascades South).

Lower snowpack may reduce springtime and summertime flows and potentially impact refill ability. This could lead to reduced ability to generate power in the spring and summer. Increasing air temperatures are likely to increase demand for power in the summer due to increased cooling loads. Decreases in power generation would incrementally increase stress on existing congested paths (i.e., South of Allston and Cross Cascades South).

Projected decreases in summer base flows from climate change combined with expected lower summer reservoir levels from spring drawdowns that last past April under the near-term operations measure would likely result in further reductions of power generation during the summer compared to the No Action Alternative.

After the fall drawdowns under this alternative, there would be additional storage space in the reservoirs compared to the No Action Alternative. Despite increasing winter inflows from climate change, this additional storage capacity would allow these inflows to be stored so that downstream winter flow releases would be similar to existing No Action Alternative conditions. This could mean little negative impact to power generation due to the drawdowns from the existing No Action Alternative condition during these times.

Reduced reservoir levels associated with decreased refill ability or drawdowns, combined with anticipated increases in the likelihood of extreme wildfire or weather events, would incrementally increase the risks that Cougar Dam would be unable to provide power during periods of reduced reservoir levels to the community of Blue River in the event a fire or severe weather event were to cause a transmission outage between Blue River and Thurston substations. Nighttime regulating outlet prioritization conditions at Hills Creek Dam would incrementally increase the risks that the dam would be unable to provide power during evening hours to the community of Oakridge if a fire or weather event were to cause a transmission outage between Oakridge and Lookout Point Substation. These risks would be greater than the No Action Alternative and would be commensurate with the duration and timing of reduced reservoir levels or nighttime prioritization through regulating outlets.

These potential climate change impacts to hydropower are based on the climate change impacts as described in the hydrologic processes section.

#### *3.12.2.5 Alternative 2B -- Hybrid Alternative*

##### *3.12.2.5.1 Changes in Power Generation*

Table 3.12-15 and Figure 3.12-9 present the generation results of the combined WVS projects for the No Action Alternative and Alternative 2B and differences by month. Overall, generation from the WVS projects would decrease from 171 aMW under the No Action Alternative, on average, over all water years, to 153 aMW under Alternative 2B. This represents a decrease of 18 aMW, which is a 10.5 percent decrease in annual average generation. The change in critical water year generation from 150 aMW under the No Action Alternative to 136 aMW under Alternative 2B represents a 14 aMW (or 9.3 percent) decrease.

**Table 3.12-15.-73 Year Average Generation (Water Years 1935/36 through 2007/08) and Critical Water Year (CWY, 1937) Average Generation at the WVS Projects: Alternative 2B (ALT2B) relative to No Action Alternative (NAA), in aMW.1**

| | AVG GEN NAA | AVG GEN ALT2B | AVG GEN Difference | CWY GEN NAA | CWY GEN ALT2B | CWY GEN Difference |
|---|---|---|---|---|---|---|
| Oct | 134 | 147 | 13 | 119 | 113 | 17 |
| Nov | 230 | 189 | -41 | 156 | 126 | 7 |
| Dec | 231 | 164 | -67 | 80 | 66 | -16 |
| Jan | 235 | 199 | -36 | 47 | 33 | -8 |
| Feb | 147 | 141 | -6 | 67 | 50 | -10 |
| Mar | 143 | 121 | -22 | 121 | 67 | -43 |
| Apr I | 177 | 138 | -39 | 188 | 163 | -6 |
| Apr II | 182 | 132 | -50 | 227 | 184 | 0 |
| May | 222 | 183 | -39 | 356 | 306 | -26 |
| Jun | 162 | 169 | 7 | 264 | 272 | 27 |
| Jul | 106 | 115 | 9 | 111 | 123 | 25 |
| Aug I | 114 | 119 | 5 | 115 | 123 | 7 |
| Aug II | 118 | 121 | 3 | 124 | 127 | 5 |
| Sep | 151 | 157 | 6 | 155 | 179 | 22 |
| **Annual Average[2]** | **171** | **153** | **-18** | **150** | 136 | **-14** |

1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

2/ The Annual Average is a weighted average to account for the different number of days in the 14 periods.

Source: HYDSIM modeling results.

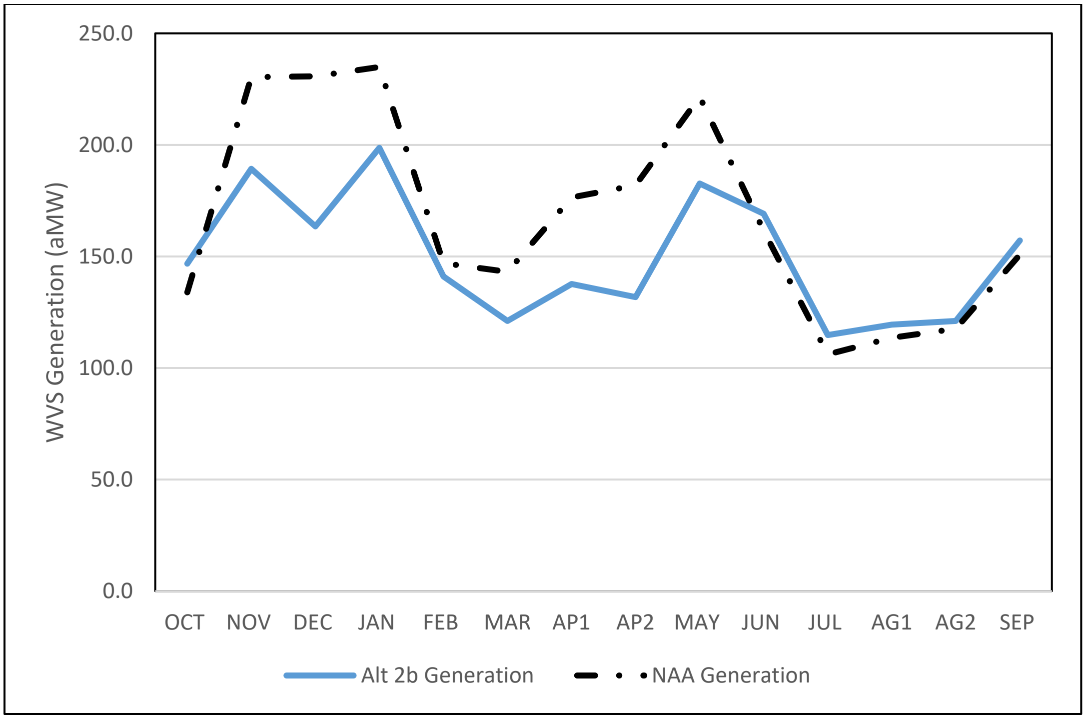


**Figure 3.12-9. Monthly Average Generation (aMW) at the WVS Projects, Alternative 2B and No Action Alternative.**

### *3.12.2.5.2 Effects on Power System Reliability*

Due to the slight decrease in total hydropower generation under Alternative 2B, the LOLP would be 6.6 percent, or 0.1 percentage points greater than the LOLP in the No Action Alternative. The LOLP change from the No Action Alternative (6.5 percent) to Alternative 2B (6.6 percent) are negligible (i.e., within the +/- 1 percent range of modeling accuracy). A 6.6 percent LOLP is roughly equivalent to a one-in-fifteen year likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions), which is the same likelihood of an event(s) as the No Action Alternative.

### *3.12.2.5.3 Potential Replacement Resources and Associated Costs*

Given that the LOLP is not materially different between Alternative 2B and the No Action Alternative, the analysis finds that no replacement resources would occur under Alternative 2B to return the LOLP to the No Action Alternative level. Though greater than the NW Council's standard of five percent, the 6.6 percent LOLP under Alternative 2B is within the reasonable historical range of the NW Council target.

### *3.12.2.5.4 Effects on Transmission*

Overall, changes in the patterns of WVS project generation under Alternative 2B would have moderate impacts to the transmission system due to the need to replace generation from more distant sources. The congested path of Cross Cascades South and South of Allston would see an increase of 21.9MW and 8.3MW in the Winter Peak case, respectively, and an increase of 25.1MW and 5.1MW in the Spring Off-peak case, respectively. For local impacts, generation at Hills Creek Dam would continue to be able to operate islanded (isolated) from the rest of the power system, providing power to the community of Oakridge during temporary power system outages primarily due to weather events or fires. Whereas, deep fall and spring drawdowns of the Cougar reservoir would likely compromise the ability of Cougar Dam to provide power to the community of Blue River in the event of a fire or severe weather event causing a temporary transmission outage between Blue River and Thurston substations.

Tables depicting power flows on Bonneville Transmission Network Paths under different seasonal conditions for Alternative 2B with comparison to the No Action Alternative are presented in Appendix G, Power and Transmission.

#### *3.12.2.5.5 Effects on Economic Viability Of Power Generation*

Under Alternative 2B, power generation from the combined WVS projects would not be economically viable. Over the 30-year study period, power operations are estimated to have a median Net Present Value of -$708 million under Alternative 2B[37]. This is a $933 million, or 415 percent, reduction in Net Present Value compared to the No Action Alternative. Across the 1,600 iterations that varied energy prices and water conditions, only 1.31 percent resulted in a positive Net Present Value. The median Levelized Cost of Generation for the combined WVS projects is estimated to rise from $26.70/MWh under the No Action Alternative to $50.66/MWh under Alternative 2B, which is a $23.96, or 90 percent, increase. This is substantially greater than expected market prices and less competitive compared to other renewable resources that are expected to become more affordable in the future.

Looking at individual projects,[38]Hills Creek is the only WVS project under Alternative 2B that has a positive median Net Present Value at $39 million. Its levelized cost of generation is $21.95/MWh. Hills Creek is the only project that has a positive Net Present Value in more than 50% of the 1600 iterations from the economic analysis. Other projects have negative median Net Present Values ranging from -$30 million (Lookout Point/Dexter) to -$354 million (Detroit/Big Cliff); levelized costs of generation ranging from $34.52/MWh (Lookout

[37] Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher. Additionally, structural cost estimates used in the analysis were at a conceptual design level with a 50% contingency. For other projects of similar size and complexity, the conceptual design cost estimates increased by 137% to 215% upon completion of the detailed design report. Post-construction, the complexity of these systems has typically resulted in further costs to improve performance. Higher implementation costs than currently estimated would result in additional reductions of the Net Present Value and increases in the levelized costs of generation.

[38] Cougar and Hills Creek dams are operated as individual projects. Additionally, peaking dams and their respective re-regulating dams are functionally operated together as individual projects; therefore, the combined peaking/reregulating dams (Detroit/Big Cliff, Green Peter/Foster, and Lookout Point/Dexter) are treated as individual projects.

Point/Dexter) to $340.57 MWh (Cougar)and proportion of 1,600 iterations resulting in a positive Net Present Value ranging from 0 percent (Cougar) to 0.2 percent (Detroit/Big Cliff).

Tables depicting 30-year Net Present Value, Percent of Iterations with a Positive Net Present Value, and Levelized Cost of Generation for WVS projects are presented in Appendix G, *Power and Transmission*.

#### *3.12.2.5.6 Summary of Effects*

Table 3.12-16 presents generation, power system reliability, transmission flow paths and reliability, and economic conditions under the No Action Alternative with comparison to Alternative 2B. Under Alternative 2B, hydropower generation from the WVS projects would decrease by 18 aMW (roughly the amount of power consumed by 14,334 Northwest homes in a year) relative to the No Action Alternative on average under historical water conditions. The WVS projects would lose 12 aMW of firm power production under critical water conditions. Alternative 2B increases the LOLP to 6.6 percent associated with the loss in generation and no replacement resources would occur since this 0.1 percent difference relative to the No Action Alternative is within the +/-1 range of the accuracy of the model. The LOLP is within the reasonable historical range of the NW Council target. Therefore, impacts to power system reliability would be negligible.

Under Alternative 2B, moderate impacts on the Cross Cascades South transmission path would be expected. There would be an increase of 25.1MW on the Cross Cascades South path. Under fall and spring deep drawdown conditions, the ability for Cougar Dam to serve load to the community of Blue River during temporary transmission outages that may occur is expected to be compromised.

Under Alternative 2B, power generation from the combined WVS projects would not be economically viable. There would be a $933 million reduction in Net Present Value and a $23.96/MWh increase in the median Levelized Cost of Generation compared to the No Action Alternative[18]. Under Alternative 2B, long-term, major, adverse effects on economic viability of power generation are anticipated.

**Table 3.12-16. Summary of Effects under Alternative 2B (ALT2B).[5]**

| Metrics | No Action Alternative | ALT2B | ALT2B relative to No Action |
|---|---|---|---|
| WVS Projects 73-Year Average Generation (aMW) | 171 | 153 | -18 |
| WVS Projects Critical Water year (1937) Average Generation (aMW) | 150 | 136 | -12 |
| Loss of Load Probability (LOLP) | 6.5% | 6.6% | +0.1[2] |
| Resource Replacement | ——[1] | N/A[2] | N/A[2] |
| Transmission Flow Paths[3]<br>Cross Cascades South | W 6475.5<br>SP 4100.5 | W 6497.4<br>SP 4125.6 | W +21.9<br>SP +25.1 |

| Metrics | No Action Alternative | ALT2B | ALT2B relative to No Action |
|---|---|---|---|
| | SU 5862.9 | SU 5858.6 | SU -4.3 |
| South of Allston | W 1183.0<br>SP 732.1<br>SU 2525.1 | W 1191.3<br>SP 737.2<br>SU 2523.8 | W +8.3<br>SP +5.1<br>SU -1.3 |
| Transmission Reliability | Same/similar to affected environment4 | Regionally- Same/similar to NAA<br>Locally: unable to operate islanded at Cougar Dam during deep fall and spring drawdowns under certain conditions | No change regionally; comprised ability to meet local transmission services at Blue River during weather or fire related temporary outages |
| Net Present Value (median) | $225 Million | -$708 million | -$863 million |
| Levelized Cost of Generation ($/MWh) | $26.70 | $50.66 | +$23.96 |

Note: The estimated LOLP effect, and resulting transmission and economic viability effects, rely on the best available information regarding planned coal plant retirements as of 2017.

1/ A "——" indicates an effect category that is not relevant to the No Action Alternative because it only has potential to occur as a result of implementing an Action Alternative (e.g., the need for new generation and transmission infrastructure and associated costs).

2/ No replacement resources would be needed to return the LOLP to the No Action Alternative level since this difference of 0.1 percent is within the +/-1 range of the accuracy of the model; LOLP is within the reasonable historical range of the NW Council target.

3/ The amount of loading (in MW) on the congested paths of Cross Cascades South (CCS) and South of Allston (SOA) are depicted during three seasonal cases (W= Winter Peak; SP= Spring Off-peak; SU= Summer Peak).

4/The congested paths of Cross Cascades South (CCS) and South of Allston (SOA) remain congested. Generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages due to, especially, weather events or fires.

5/Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher. Additionally, structural cost estimates used in the analysis were at a conceptual design level with a 50% contingency. For other projects of similar size and complexity, the conceptual design cost estimates increased by 137% to 215% upon completion of the detailed design report. Post-construction, the complexity of these systems has typically resulted in further costs to improve performance. Higher implementation costs than currently estimated would result in additional reductions of the Net Present Value and increases in the levelized costs of generation.

#### *3.12.2.5.7 Alternative 2B Climate Change Impacts for Power Generation and Transmission*

Since the WVS will likely experience increasing winter time (December through March) flow volumes due to climate change generally, it is possible that projects may be able to capture some additional flow and produce incremental increases in power generation during the winter. However, higher projected air temperatures are likely to result in decreased heating loads. Increases in power generation would incrementally decrease stress on existing congested paths (i.e., South of Allston and Cross Cascades South).

Lower snowpack may reduce springtime and summertime flows, as well as potentially impact refill ability. This could lead to reduced ability to generate power in the spring and summer. Increasing air temperatures are likely to increase demand for power in the summer due to increased cooling loads. Decreases in power generation would incrementally increase stress on existing congested paths (i.e., South of Allston and Cross Cascades South).

Climate change would affect Alternative 2B similar to the No Action Alternative with regards to hydropower. Under Alternative 2B, there may be the potential to release and store more water in the spring and summer of dry years as compared to the No Action Alternative. The flow targets in Alternative 2B are lower than the current flow requirements, the reservoir may be able to store more water. However, the projects would likely have to use more of the stored water later in the season due to the projected variability in the spring months, hotter, drier summers, and lower summer base flow due to climate change.

Reservoirs in Alternative 2B sometimes drop to minimum elevation during the summer, but less often than the No Action Alternative, meaning storage levels would generally be able to augment summer flow for longer than the No Action Alternative even with projected decline in later spring and summer flows. This may alleviate some of the projected decrease in power generation in the summer from climate change than would occur under the No Action Alternative.

Reduced reservoir levels associated with decreased refill ability or drawdowns, combined with anticipated increases in the likelihood of extreme wildfire or weather events, would incrementally increase the risks that Cougar Dam would be unable to provide power during periods of reduced reservoir levels to the community of Blue River in the event a fire or severe weather event were to cause a transmission outage between Blue River and Thurston substations. Similarly, these conditions would incrementally increase the risks that Hills Creek Dam would be unable to provide power during periods of reduced reservoir levels to the community of Oakridge if a fire or weather event were to cause a transmission outage between Oakridge and Lookout Point Substation. These risks would be greater than the No Action Alternative and would be commensurate with the duration and timing of reduced reservoir levels.

These potential climate change impacts to hydropower are based on the climate change impacts as described in the hydrologic processes section.

#### *3.12.2.5.8 Evaluation of Near-Term Operations Measure*

See Alternative 2A, Section 3.12.2.3.8, for description of effects due to the Near-Term Operations Measure.

### ***3.12.2.6 Alternative 3A – Operations-Focused Fish Passage Alternative***

#### *3.12.2.6.1 Changes in Power Generation*

Table 3.12-17 and Figure 3.12-10 present the generation results of the combined WVS projects for the No Action Alternative and Alternative 3A and differences by month. Overall, generation from the WVS projects would decrease from 171 aMW under the No Action Alternative, on average, over all water years, to 84 aMW under Alternative 3A. This represents a decrease of 87 aMW, which is a 50.9 percent decrease in average annual generation. The change in critical water year generation from 150 aMW under the No Action Alternative to 60 aMW under Alternative 3A represents a 90 aMW (or 60 percent) decrease.

**Table 3.12-17. 73-Year Average Generation (Water Years 1935/36 through 2007/08) and Critical Water Year (CWY, 1937) Average Generation at the WVS Projects: Alternative 3A (ALT3A) relative to No Action Alternative (NAA), in aMW.[1]**

| | AVG GEN NAA | AVG GEN ALT3A | AVG GEN Difference | CWY GEN NAA | CWY GEN ALT3A | CWY GEN Difference |
|---|---|---|---|---|---|---|
| Oct | 134 | 51 | -83 | 119 | 36 | -83 |
| Nov | 230 | 48 | -182 | 156 | 12 | -144 |
| Dec | 231 | 83 | -148 | 80 | 22 | -58 |
| Jan | 235 | 175 | -60 | 47 | 21 | -26 |
| Feb | 147 | 164 | 17 | 67 | 38 | -29 |
| Mar | 143 | 115 | -28 | 121 | 56 | -65 |
| Apr I | 177 | 96 | -81 | 188 | 125 | -63 |
| Apr II | 182 | 71 | -111 | 227 | 138 | -89 |
| May | 222 | 45 | -177 | 356 | 67 | -289 |
| Jun | 162 | 43 | -119 | 264 | 67 | -197 |
| Jul | 106 | 53 | -53 | 111 | 80 | -31 |
| Aug I | 114 | 58 | -56 | 115 | 69 | -46 |
| Aug II | 118 | 66 | -52 | 124 | 66 | -58 |
| Sep | 151 | 92 | -59 | 155 | 125 | -30 |
| **Annual Average[2]** | **171** | **84** | **-87** | **150** | **60** | **-90** |

1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

2/ The Annual Average is a weighted average to account for the different number of days in the 14 periods.

Source: HYDSIM modeling results.

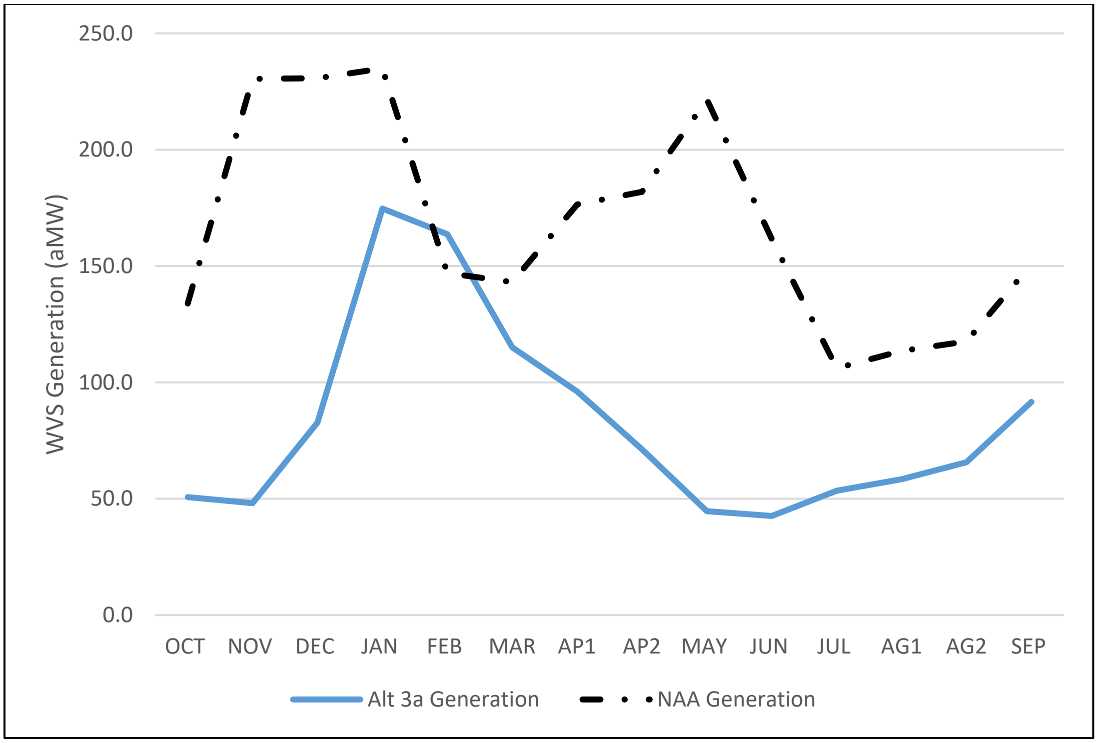


**Figure 3.12-10. Monthly Average Generation (aMW) at the WVS Projects, Alternative 3A and No Action Alternative.**

#### *3.12.2.6.2 Effects on Power System Reliability*

Due to the decrease in total hydropower generation under Alternative 3A, the LOLP would be seven percent, or 0.5 percentage points greater than the LOLP in the No Action Alternative. The LOLP change from the No Action Alternative (6.5 percent) to Alternative 3A (7.0 percent) is negligible (i.e., within the +/- 1 percent range of modeling accuracy). A seven percent LOLP is roughly equivalent to a one-in-fifteen year likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions), which is the same likelihood of an event(s) as the No Action Alternative.

#### *3.12.2.6.3 Potential Replacement Resources and Associated Costs*

Given that the LOLP is not materially different between Alternative 3A and the No Action Alternative, the analysis finds that no replacement resources would occur under Alternative 3A to return the LOLP to the No Action Alternative level. Though greater than the NW Council's standard of five percent, the seven percent LOLP under Alternative 3A is within the reasonable historical range of the NW Council target.

#### *3.12.2.6.4 Effects on Transmission*

Overall, changes in the patterns of WVS projects generation under Alternative 3A would have moderate impacts to the transmission system due to the need to replace generation from more distant sources. Studies showed the congested path of Cross Cascades South and South of

Allston increased 37.2MW and 13.6MW in the Winter Peak case, respectively. Also, studies showed the congested paths of Cross Cascades South and South of Allston increased 113.7 MW and 22.3 MW in the Spring Off-peak case, respectively. Studies showed an increase of 28.3 MW for Cross Cascades South in the Summer Peak case. Deep fall and spring drawdowns at Hills Creek reservoir may compromise the ability to provide power to Oakridge during transmission system outages. There is little redundancy for Oakridge, and the loss of the Hills Creek – Lookout Point 115kV transmission line would cause a loss of power to Oakridge if Hills Creek Dam generation is not available. Recent weather trends suggest at least one winter storm serious enough to cause an outage of this transmission line could be expected annually. The durations of the recent outages have ranged from approximately two hours to two weeks. Wildfire could have similar or greater impact. Similarly, deep fall and spring drawdowns of the Cougar reservoir would likely compromise the ability of Cougar Dam to provide power to the community of Blue River in the event of a fire or severe storm causing a transmission outage between Blue River and Thurston substations.

Tables depicting power flows on Bonneville Transmission Network Paths under different seasonal conditions for Alternative 3A with comparison to the No Action Alternative are presented in Appendix G, Power and Transmission.

###### *3.12.2.6.5 Effects on Economic Viability of Power Generation*

Under Alternative 3A, power generation from the combined WVS projects would not be economically viable. Over the 30-year study period, power operations are estimated to have a median Net Present Value of -$628 million under Alternative 3A[39]. This is an $853 million, or 379 percent, reduction in Net Present Value compared to the No Action Alternative. Across the 1,600 iterations that varied energy prices and water conditions, only 0.3 percent resulted in a positive Net Present Value. The median Levelized Cost of Generation for the combined WVS projects is estimated to rise from $26.70/MWh under the No Action Alternative to $64.32/MWh under Alternative 3A, which is a $37.61, or 141 percent, increase. This is substantially greater than expected market prices and less competitive compared to other renewable resources that are expected to become more affordable in the future.

Looking at individual projects,[40] all of the WVS projects under Alternative 3A have negative median Net Present Values ranging from -$41 million (Hills Creek) to -$189 million (Detroit/Big

[39] Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher. Additionally, structural cost estimates used in the analysis were at a conceptual design level with a 50% contingency. For other projects of similar size and complexity, the conceptual design cost estimates increased by 137% to 215% upon completion of the detailed design report. Post-construction, the complexity of these systems has typically resulted in further costs to improve performance. Higher implementation costs than currently estimated would result in additional reductions of the Net Present Value and increases in the levelized costs of generation.

[40] Cougar and Hills Creek dams are operated as individual projects. Additionally, peaking dams and their respective re-regulating dams are functionally operated together as individual projects; therefore, the combined peaking/reregulating dams (Detroit/Big Cliff, Green Peter/Foster, and Lookout Point/Dexter) are treated as individual projects.

Cliff) and levelized costs of generation ranging from $44.79/MWh (Hills Creek) to $81.57/MWh (Detroit/Big Cliff); and a proportion of 1,600 iterations resulting in a positive Net Present Value ranging from 0.25 percent (Cougar) to 6.7 percent (Hills Creek).

Tables depicting 30-year Net Present Value, Percent of Iterations with a Positive Net Present Value, and Levelized Cost of Generation for WVS projects are presented in Appendix G, *Power and Transmission*.

##### *3.12.2.6.6 Summary of Effects*

Table 3.12-18 presents generation, power system reliability, transmission flow paths and reliability, and economic conditions under the No Action Alternative with comparison to Alternative 3A. Under Alternative 3A, hydropower generation from the WVS projects would decrease by 87 aMW (roughly the amount of power consumed by 69,283 Northwest homes in a year) relative to the No Action Alternative on average under historical water conditions. The WVS projects would lose 90 aMW of firm power production under critical water conditions.

Alternative 3A increases the LOLP to seven percent associated with the loss in generation and no replacement resources would occur since this 0.5 percent difference relative to the No Action Alternative is within the +/-1 range of the accuracy of the model. The LOLP is within the reasonable historical range of the NW Council target. Therefore, impacts to power system reliability would be negligible.

A moderate impact on the Cross Cascades South transmission path would be expected. The ability for Hills Creek and Cougar to support the communities of Oakridge and Blue River, respectively, during temporary transmission outages that may occur is expected to be compromised.

Under Alternative 3A, power generation from the combined WVS projects would not be economically viable. There would be an $853 million reduction in Net Present Value and a $37.61/MWh increase in the median Levelized Cost of Generation compared to the No Action Alternative[20]. Under Alternative 3A, long-term, major, adverse effects on economic viability of power generation are anticipated.

**Table 3.12-18. Summary of Effects under Alternative 3A (ALT3A).[5]**

| Metrics | No Action Alternative | ALT3A | ALT3A relative to No Action |
|---|---|---|---|
| WVS Projects 73-Year Average Generation (aMW) | 171 | 84 | -87 |
| WVS Projects Critical Water year (1937) Average Generation (aMW) | 150 | 60 | -90 |
| Loss of Load Probability (LOLP) | 6.5% | 7.0% | 0.5[a] |
| Resource Replacement | ——[1] | N/A[a] | N/A[a] |

| Metrics | No Action Alternative | ALT3A | ALT3A relative to No Action |
|---|---|---|---|
| Transmission Flow Paths[3]<br>Cross Cascades South | W 6475.5<br>SP 4100.5<br>SU 5862.9 | W 6512.7<br>SP 4214.2<br>SU 5891.2 | W +37.2<br>SP +113.7<br>SU +28.3 |
| South of Allston | W 1183.0<br>SP 732.1<br>SU 2525.1 | W 1196.6<br>SP 754.4<br>SU 2535.4 | W +13.6<br>SP +22.3<br>SU +10.3 |
| Transmission Reliability | Same/similar to affected environment[4] | Regionally-Same/similar to NAA<br>Locally: unable to operate islanded at Hills Creek and Cougar dams during deep fall and spring drawdowns under certain conditions | No change regionally; comprised ability to meet local transmission services at Oakridge and Blue River during weather or fire related temporary outages |
| Net Present Value (median) | $225 Million | -$628 million | -$853 million |
| Levelized Cost of Generation ($/MWh) | $26.70 | $64.32 | +$37.61 |

Note: The estimated LOLP effect, and resulting transmission and economic viability effects, rely on the best available information regarding planned coal plant retirements as of 2017.

1/ A "——" indicates an effect category that is not relevant to the No Action Alternative because it only has potential to occur as a result of implementing an Action Alternative (e.g., the need for new generation and transmission infrastructure and associated costs).

2/ No replacement resources would be needed to return the LOLP to the No Action Alternative level since this difference of 0.1 percent is within the +/-1 range of the accuracy of the model; LOLP is within the reasonable historical range of the NW Council target.

3/ The amount of loading (in MW) on the congested paths of Cross Cascades South (CCS) and South of Allston (SOA) are depicted during three seasonal cases (W= Winter Peak; SP= Spring Off-peak; SU= Summer Peak).

4/ The congested paths of Cross Cascades South (CCS) and South of Allston (SOA) remain congested. Generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages due to, especially, weather events or fires.

5/Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher. Additionally, structural cost estimates used in the analysis were at a conceptual design level with a 50% contingency. For other projects of similar size and complexity, the conceptual design cost estimates increased by 137% to 215% upon completion of the detailed design report. Post-construction, the complexity of these systems has typically resulted in further costs to improve performance. Higher implementation costs than currently estimated would result in additional reductions of the Net Present Value and increases in the levelized costs of generation.

#### *3.12.2.6.7 Alternative 3A Climate Change Impacts for Power Generation and Transmission*

Since the WVS will likely experience increasing winter time (December through March) flow volumes due to climate change generally, it is possible that projects may be able to capture some additional flow and produce incremental increases in power generation during the winter. However, higher projected temperatures are likely to result in decreased heating loads. Increases in power generation would incrementally decrease stress on existing congested paths (i.e., South of Allston and Cross Cascades South).

Lower snowpack may reduce springtime and summertime flows, as well as potentially impact refill ability. This could lead to reduced ability to generate power in the spring and summer. Increasing air temperatures are likely to increase demand for power in the summer due to increased cooling loads. Decreases in power generation would incrementally increase stress on existing congested paths (i.e., South of Allston and Cross Cascades South).

Projected decreases in summer base flows from climate change combined with expected lower summer reservoir levels from spring drawdowns that last past April under Alternative 3A would likely result in further reductions of power generation during the summer compared to the No Action Alternative.

After the fall drawdowns under this alternative, there would be additional storage space in the reservoirs compared to the No Action Alternative. Despite increasing winter inflows from climate change, this additional storage capacity would allow these inflows to be stored so that downstream winter flow releases would be similar to existing No Action Alternative conditions. This could mean little negative impact to power generation due to the drawdowns from the existing No Action Alternative condition during these times.

Reduced reservoir levels associated with decreased refill ability or drawdowns, combined with anticipated increases in the likelihood of extreme wildfire or weather events, would incrementally increase the risks that Cougar Dam would be unable to provide power during periods of reduced reservoir levels to the community of Blue River in the event a fire or severe weather event were to cause a transmission outage between Blue River and Thurston substations. Similarly, these conditions would incrementally increase the risks that Hills Creek Dam would be unable to provide power during periods of reduced reservoir levels to the community of Oakridge if a fire or weather event were to cause a transmission outage between Oakridge and Lookout Point Substation. These risks would be greater than the No Action Alternative and would be commensurate with the duration and timing of reduced reservoir levels.

These potential climate change impacts to hydropower are based on the climate change impacts as described in the hydrologic processes section.

#### *3.12.2.6.8 Evaluation of Near-Term Operations Measure*

See Alternative 2A, Section 3.12.2.3.8, for description of effects due to the Near-Term Operations Measure.

### ***3.12.2.7 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at COU)***

#### *3.12.2.7.1 Changes in Power Generation*

Table 3.12-19 and Figure 3.12-11 present the generation results of the combined WVS projects for the No Action Alternative and Alternative 3B and differences by month. Overall, generation from the WVS projects would decrease from 171 aMW under the No Action Alternative, on average, over all water years, to 93 aMW under Alternative 3B. This represents a decrease of 79 aMW, which is a 45.6 percent decrease in average annual generation. The change in critical water year generation from 150 aMW under the No Action Alternative to 67 aMW under Alternative 3B represents an 83 aMW (or 55.3 percent) decrease.

**Table 3.12-19.-73 Year Average Generation (Water Years 1935/36 through 2007/08) and Critical Water Year (CWY, 1937) Average Generation at the WVS Projects: Alternative 3B (ALT3B) relative to No Action Alternative (NAA), in aMW.[1]**

| | AVG GEN NAA | AVG GEN ALT3B | AVG GEN Difference | CWY GEN NAA | CWY GEN ALT3B | CWY GEN Difference |
|---|---|---|---|---|---|---|
| Oct | 134 | 57 | -77 | 119 | 45 | -74 |
| Nov | 230 | 43 | -187 | 156 | 14 | -142 |
| Dec | 231 | 72 | -159 | 80 | 17 | -63 |
| Jan | 235 | 167 | -68 | 47 | 15 | -32 |
| Feb | 147 | 185 | 38 | 67 | 30 | -37 |
| Mar | 143 | 132 | -11 | 121 | 69 | -52 |
| Apr I | 177 | 118 | -59 | 188 | 106 | -82 |
| Apr II | 182 | 82 | -100 | 227 | 103 | -124 |
| May | 222 | 68 | -154 | 356 | 105 | -251 |
| Jun | 162 | 55 | -106 | 264 | 84 | -180 |
| Jul | 106 | 62 | -44 | 111 | 88 | -23 |
| Aug I | 114 | 60 | -54 | 115 | 76 | -39 |
| Aug II | 118 | 75 | -43 | 124 | 91 | -33 |
| Sep | 151 | 112 | -39 | 155 | 152 | -3 |
| **Annual Average[2]** | **171** | **93** | **-79** | **150** | **67** | **-83** |

1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

2/ The Annual Average is a weighted average to account for the different number of days in the 14 periods.

Source: HYDSIM modeling results.

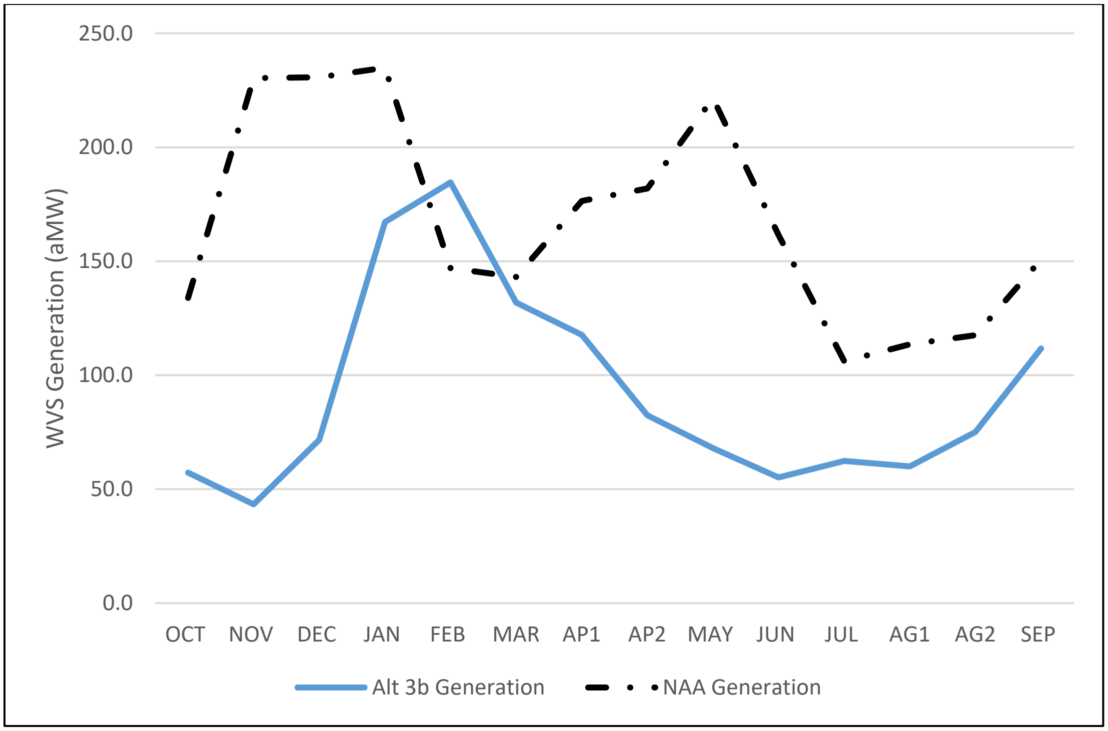


**Figure 3.12-11. Monthly Average Generation (aMW) at the WVS Projects, Alternative 3B and No Action Alternative.**

*3.12.2.7.2 Effects on Power System Reliability*

Due to the decrease in total hydropower generation under Alternative 3B, the LOLP would be seven percent, or 0.5 percentage points greater than the LOLP in the No Action Alternative. The LOLP change from the No Action Alternative (6.5 percent) to Alternative 3B (seven percent) are negligible (i.e., within the +/- 1 percent range of modeling accuracy). A seven percent LOLP is roughly equivalent to a one-in-fifteen year likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions), which is the same likelihood of an event(s) as the No Action Alternative.

*3.12.2.7.3 Potential Replacement Resources and Associated Costs*

Given that the LOLP is not materially different between Alternative 3B and the No Action Alternative, the analysis finds that no replacement resources would occur under Alternative 3B to return the LOLP to the No Action Alternative level. Though greater than the NW Council's standard of five percent, the seven percent LOLP under Alternative 3B is within the reasonable historical range of the NW Council target.

*3.12.2.7.4 Effects on Transmission*

Overall, changes in the patterns of WVS projects generation under Alternative 3B would have moderate impacts to the transmission system due to the need to replace generation from more distant sources. Studies showed the congested path of Cross Cascades South and South of

Allston increased 41.4MW and 15.2MW in the Winter Peak case, respectively. Also, studies showed the congested paths of Cross Cascades South and South of Allston increased 94.8MW and 18.7MW in the Spring Off-peak case, respectively. Studies showed an increase of 25.6MW for Cross Cascades South in the Summer Peak case. Deep fall and spring drawdowns at Hills Creek reservoir may compromise the ability to serve load to Oakridge during transmission system outages. There is little redundancy for Oakridge, and the loss of the Hills Creek – Lookout Point 115kV transmission line would cause a loss of power to Oakridge if Hills Creek generation is not available. Recent weather trends suggest at least one winter storm serious enough to cause an outage of this transmission line could be expected annually. The durations of the recent outages have ranged from approximately two hours to two weeks. Wildfire could have similar or greater impact. Similarly, deep fall and spring drawdowns of the Cougar reservoir would likely compromise the ability of Cougar Dam to provide power to the community of Blue River in the event of a fire or severe storm causing a transmission outage between Blue River and Thurston substations.

Tables depicting power flows on Bonneville Transmission Network Paths under different seasonal conditions for Alternative 3B with comparison to the No Action Alternative are presented in Appendix G, Power and Transmission.

#### *3.12.2.7.5 Effects on Economic Viability of Power Generation*

Under Alternative 3B, power generation from the combined WVS projects would not be economically viable. Over the 30-year study period, power operations are estimated to have a median Net Present Value of -$604 million under Alternative 3B[41]. This is an $829 million, or 369 percent, reduction in Net Present Value compared to the No Action Alternative. Across the 1,600 iterations that varied energy prices and water conditions, only 0.5 percent resulted in a positive Net Present Value. The median Levelized Cost of Generation for the combined WVS projects is estimated to rise from $26.70/MWh under the No Action Alternative to $59.42/MWh under Alternative 3B, which is a $32.72, or 123 percent, increase). This is substantially greater than expected market prices and less competitive compared to other renewable resources that are expected to become more affordable in the future.

Looking at individual projects[42], all of the WVS projects have negative median Net Present Values ranging from -$68 million (Hills Creek) to -$231 million (Green Peter/Foster) and their

[41] Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher. Additionally, structural cost estimates used in the analysis were at a conceptual design level with a 50% contingency. For other projects of similar size and complexity, the conceptual design cost estimates increased by 137% to 215% upon completion of the detailed design report. Post-construction, the complexity of these systems has typically resulted in further costs to improve performance. Higher implementation costs than currently estimated would result in additional reductions of the Net Present Value and increases in the levelized costs of generation.

[42] Cougar and Hills Creek dams are operated as individual projects. Additionally, peaking dams and their respective re-regulating dams are functionally operated together as individual projects; therefore, the combined peaking/reregulating dams (Detroit/Big Cliff, Green Peter/Foster, and Lookout Point/Dexter) are treated as individual projects.

levelized costs of generation range from $41.25/MWh (Detroit/Big Cliff) to $346.18/MWh (Cougar). None of the projects had a positive Net Present Value in more than 50% of the iterations, with the proportion of 1,600 iterations resulting in a positive Net Present Value ranging from 0 percent (Cougar) to 12.69 percent (Detroit/Big Cliff).

Tables depicting 30-year Net Present Value, Percent of Iterations with a Positive Net Present Value, and Levelized Cost of Generation for WVS projects are presented in Appendix G, *Power and Transmission*.

#### *3.12.2.7.6 Summary of Effects*

Table 3.12-20 presents generation, power system reliability, transmission flow paths and reliability, and economic conditions under the No Action Alternative with comparison to Alternative 3B. Under Alternative 3B, annual average hydropower generation from the WVS projects would decrease by 79 aMW (roughly the amount of power consumed by 62,912 Northwest homes in a year) relative to the No Action Alternative. The WVS projects would lose 83 aMW of firm power production under critical water conditions. Alternative 3B increases the LOLP to seven percent associated with the loss in generation and no replacement resources would occur since this 0.5 percent difference relative to the No Action Alternative is within the +/-1 range of the accuracy of the model. The LOLP is within the reasonable historical range of the NW Council target. Therefore, impacts to power system reliability would be negligible.

A moderate impact on the Cross Cascades South transmission path would be expected. The ability for Hills Creek and Cougar to support the communities of Oakridge and Blue River, respectively, during transmission outages that may occur is expected to be compromised.

Under Alternative 3B, power generation from the combined WVS projects would not be economically viable. There would be an $829 million reduction in Net Present Value and a $32.72/MWh increase in the median Levelized Cost of Generation compared to the No Action Alternative[22]. Under Alternative 3B, long-term, major, adverse effects on economic viability of power generation are anticipated.

**Table 3.12-20. Summary of Effects under Alternative 3B (ALT3B).[5]**

| Metrics | No Action Alternative | ALT3B | ALT3B relative to No Action |
|---|---|---|---|
| WVS Projects 73-Year Average Generation (aMW) | 171 | 93 | -79 |
| WVS Projects Critical Water year (1937) Average Generation (aMW) | 150 | 67 | -83 |
| Loss of Load Probability (LOLP) | 6.5% | 7.0% | +0.5[a] |
| Resource Replacement | ——[1] | N/A[a] | N/A[a] |

| Metrics | No Action Alternative | ALT3B | ALT3B relative to No Action |
|---|---|---|---|
| Transmission Flow Paths[3]<br>Cross Cascades South | W 6475.5<br>SP 4100.5<br>SU 5862.9 | W 6516.9<br>SP 4195.3<br>SU 5888.5 | W +41.4<br>SP +94.8<br>SU +25.6 |
| South of Allston | W 1183.0<br>SP 732.1<br>SU 2525.1 | W 1198.2<br>SP 750.8<br>SU 2534 | W +15.2<br>SP +18.7<br>SU +8.9 |
| Transmission Reliability | Same/similar to affected environment[4] | Regionally- Same/similar to NAA<br>Locally: unable to operate islanded at Hills Creek and Cougar dams during deep fall and spring drawdowns under certain conditions | No change regionally; comprised ability to meet local transmission services at Oakridge and Blue River during weather or fire related temporary outages |
| Net Present Value (median) | $225 Million | -$628 million | -$829 million |
| Levelized Cost of Generation ($/MWh) | $26.70 | $59.42 | +$32.72 |

Note: The estimated LOLP effect, and resulting transmission and economic viability effects, rely on the best available information regarding planned coal plant retirements as of 2017.

1/ A "——" indicates an effect category that is not relevant to the No Action Alternative because it only has potential to occur as a result of implementing an Action Alternative (e.g., the need for new generation and transmission infrastructure and associated costs).

2/ No replacement resources would be needed to return the LOLP to the No Action Alternative level since this difference of 0.1 percent is within the +/-1 range of the accuracy of the model; LOLP is within the reasonable historical range of the NW Council target.

3/ The amount of loading (in MW) on the congested paths of Cross Cascades South (CCS) and South of Allston (SOA) are depicted during three seasonal cases (W= Winter Peak; SP= Spring Off-peak; SU= Summer Peak).

4/ The congested paths of Cross Cascades South (CCS) and South of Allston (SOA) remain congested. Generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages due to, especially, weather events or fires.

5/Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher. Additionally, structural cost estimates used in the analysis were at a conceptual design level with a 50% contingency. For other projects of similar size and complexity, the conceptual design cost estimates increased by 137% to 215% upon completion of the detailed design report. Post-construction, the complexity of these systems has typically resulted in further costs to improve performance. Higher implementation costs than currently estimated would result in additional reductions of the Net Present Value and increases in the levelized costs of generation.

#### *3.12.2.7.7 Alternative 3B Climate Change Impacts for Power Generation and Transmission*

Since the WVS will likely experience increasing winter time (December through March) flow volumes due to climate change generally, it is possible that projects may be able to capture some additional flow and produce incremental increases in power generation during the winter. However, higher projected temperatures are likely to result in decreased heating loads. Increases in power generation would incrementally decrease stress on existing congested paths (i.e., South of Allston and Cross Cascades South).

Lower snowpack may reduce springtime and summertime flows, as well as potentially impact refill ability. This could lead to reduced ability to generate power in the spring and summer. Increasing air temperatures are likely to increase demand for power in the summer due to increased cooling loads. Decreases in power generation would incrementally increase stress on existing congested paths (i.e., South of Allston and Cross Cascades South).

Projected decreases in summer base flows from climate change combined with expected lower summer reservoir levels from spring drawdowns that last past April under Alternative 3B would likely result in further reductions of power generation during the summer compared to the No Action Alternative.

After the fall drawdowns under this alternative, there would be additional storage space in the reservoirs compared to the No Action Alternative. Despite increasing winter inflows from climate change, this additional storage capacity would allow these inflows to be stored so that downstream winter flow releases would be similar to existing No Action Alternative conditions. This could mean little negative impact to power generation due to the drawdowns from the existing No Action Alternative condition during these times.

Reduced reservoir levels associated with decreased refill ability or drawdowns, combined with anticipated increases in the likelihood of extreme wildfire or weather events, would incrementally increase the risks that Cougar Dam would be unable to provide power during periods of reduced reservoir levels to the community of Blue River in the event a fire or severe weather event were to cause a transmission outage between Blue River and Thurston substations. Similarly, these conditions would incrementally increase the risks that Hills Creek Dam would be unable to provide power during periods of reduced reservoir levels to the community of Oakridge if a fire or weather event were to cause a transmission outage between Oakridge and Lookout Point Substation. These risks would be greater than the No Action Alternative and would be commensurate with the duration and timing of reduced reservoir levels.

These potential climate change impacts to hydropower are based on the climate change impacts as described in the hydrologic processes section.

#### *3.12.2.7.8 Evaluation of Near-Term Operations Measure*

See Alternative 2A, Section 3.12.2.3.8, for description of effects due to the Near-Term Operations Measure.

### *3.12.2.8 Alternative 4 – Structures-Based Fish Passage Alternative*

#### *3.12.2.8.1 Changes in Power Generation*

Table 3.12-21 and Figure 3.12-12 present the generation results of the combined WVS projects for the No Action Alternative and Alternative 4 and differences by month. Overall, generation from the WVS projects would increase from 171 aMW under the No Action Alternative, on average, over all water years, to 172 aMW under Alternative 4. This represents an increase of 1 aMW, which is a 0.6 percent increase in average annual generation. The change in critical water year generation from 150 aMW under the No Action Alternative to 148 aMW under Alternative 4 represents a 2 aMW (or 1.3 percent) decrease.

**Table 3.12-21. 73-Year Average Generation (Water Years 1935/36 through 2007/08) and Critical Water Year (CWY, 1937) Average Generation at the WVS Projects: Alternative 4 (ALT4) relative to No Action Alternative (NAA), in aMW.[1]**

| | AVG GEN NAA | AVG GEN ALT4 | AVG GEN Difference | CWY GEN NAA | CWY GEN ALT4 | CWY GEN Difference |
|---|---|---|---|---|---|---|
| Oct | 134 | 160 | 26 | 119 | 129 | 10 |
| Nov | 230 | 250 | 20 | 156 | 174 | 18 |
| Dec | 231 | 223 | -8 | 80 | 59 | -21 |
| Jan | 235 | 228 | -7 | 47 | 36 | -11 |
| Feb | 147 | 147 | 0 | 67 | 59 | -8 |
| Mar | 143 | 132 | -11 | 121 | 115 | -6 |
| Apr I | 177 | 151 | -26 | 188 | 176 | -12 |
| Apr II | 182 | 145 | -37 | 227 | 227 | 0 |
| May | 222 | 199 | -22 | 356 | 325 | -31 |
| Jun | 162 | 189 | 27 | 264 | 285 | 21 |
| Jul | 106 | 126 | 19 | 111 | 134 | 23 |
| Aug I | 114 | 128 | 15 | 115 | 123 | 8 |
| Aug II | 118 | 130 | 13 | 124 | 126 | 2 |
| Sep | 151 | 137 | -14 | 155 | 137 | -18 |
| **Annual Average[2]** | 171 | 172 | 1 | 150 | 148 | -2 |

1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

2/ The Annual Average is a weighted average to account for the different number of days in the 14 periods.

Source: HYDSIM modeling results.

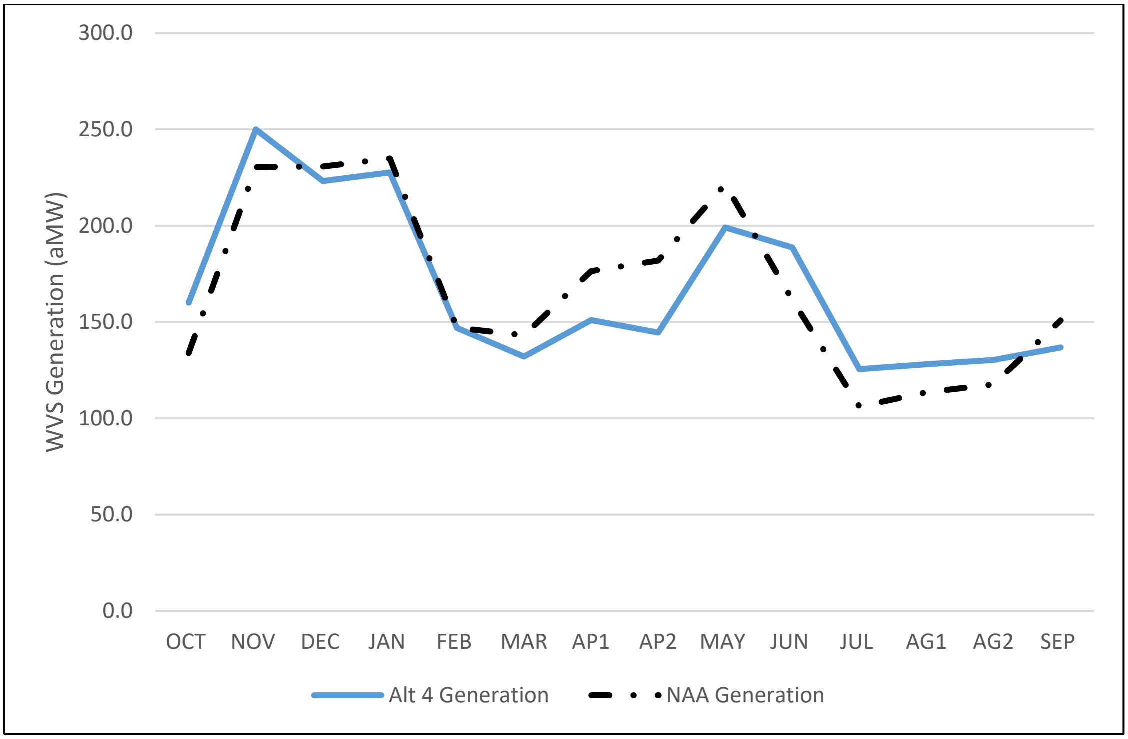


**Figure 3.12-12. Monthly Average Generation (aMW) at the WVS Projects, Alternative 4 and No Action Alternative.**

*3.12.2.8.2 Effects on Power System Reliability*

Due to the minimal decrease in total hydropower generation under Alternative 4, the LOLP would be 6.5 percent, which is the same as the No Action Alternative. A 6.5 percent LOLP is roughly equivalent to a one-in-fifteen year likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions).

*3.12.2.8.3 Potential Replacement Resources and Associated Costs*

Given that the LOLP is not materially different between Alternative 4 and the No Action Alternative, the analysis finds that no replacement resources would occur under Alternative 4 to return the LOLP to the No Action Alternative level. Though greater than the NW Council's standard of five percent, the 6.5 percent LOLP under Alternative 4 is within the reasonable historical range of the NW Council target.

*3.12.2.8.4 Effects on Transmission*

Overall, changes in the patterns of WVS projects generation under Alternative 4 would have minor impacts to the transmission system due to the need to replace generation from more distant sources. Studies showed impacts to the congested paths of Cross Cascades South and South of Allston remain congested with small (less than 10MW) increases to loading expected, with the exception that there was a slightly greater increase of 15MW on the Cross Cascades South in the Spring Off-peak case. For local impacts, generation at Hills Creek and Cougar dams would continue to be able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages primarily due to weather events or fires. Construction projects at Hills Creek and Cougar dams should not have a major impact on transmission services to Oakridge or Blue River, respectively, provided generation is not affected.

Tables depicting power flows on Bonneville Transmission Network Paths under different seasonal conditions for Alternative 4 with comparison to the No Action Alternative are presented in Appendix G, Power and Transmission.

#### 3.12.2.8.5 Effects on *Economic Viability Of Power Generation*

Under Alternative 4, power generation from the combined WVS projects would not be economically viable. Over the 30-year study period, power operations are estimated to have a median Net Present Value of -$937 million under Alternative 4[43]. This is a $1.162 billion, or 517%, reduction in Net Present Value compared to the No Action Alternative. Across the 1,600 iterations that varied energy prices and water conditions, only 0.6 percent resulted in a positive Net Present Value. The median Levelized Cost of Generation for the combined WVS projects is estimated to rise from $26.70/MWh under the No Action Alternative to $54.54/MWh under Alternative 4, which is a $27.84, or 104 percent, increase). This is substantially greater than expected market prices and less competitive compared to other renewable resources that are expected to become more affordable in the future.

Looking at individual projects[44], all of the WVS projects under Alternative 4 have negative median Net Present Values ranging from -$67 million (Hills Creek) to -$356 million (Detroit/Big Cliff) and their levelized costs of generation range from $46.48/MWh (Hills Creek) to $57.71/MWh (Detroit/Big Cliff). None of the projects had a positive Net Present Value in more than 50% of the iterations, with the proportion of 1,600 iterations resulting in a positive Net Present Value ranging from 0.2 percent (Detroit/Big Cliff) to 3.9 percent (Hills Creek).

Tables depicting 30-year Net Present Value, Percent of Iterations with a Positive Net Present Value, and Levelized Cost of Generation for WVS projects are presented in Appendix G, *Power and Transmission*.

[43] Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher. Additionally, structural cost estimates used in the analysis were at a conceptual design level with a 50% contingency. For other projects of similar size and complexity, the conceptual design cost estimates increased by 137% to 215% upon completion of the detailed design report. Post-construction, the complexity of these systems has typically resulted in further costs to improve performance. Higher implementation costs than currently estimated would result in additional reductions of the Net Present Value and increases in the levelized costs of generation.

[44] Cougar and Hills Creek dams are operated as individual projects. Additionally, peaking dams and their respective re-regulating dams are functionally operated together as individual projects; therefore, the combined peaking/reregulating dams (Detroit/Big Cliff, Green Peter/Foster, and Lookout Point/Dexter) are treated as individual projects.

#### *3.12.2.8.6 Summary of Effects*

Table 3.12-22 presents generation, power system reliability, transmission flow paths and reliability, and economic conditions under the No Action Alternative with comparison to Alternative 4. Under Alternative 4, average annual hydropower generation from the WVS projects would increase by 1 aMW (roughly the amount of power consumed by 796 Northwest homes in a year) relative to the No Action Alternative. The WVS projects would lose 2 aMW of firm power production under critical water conditions.

There is no change in the LOLP under this alternative and no replacement resources would occur. The LOLP of 6.5 percent is within the reasonable historical range of the NW Council target. Therefore, impacts to power system reliability would be negligible.

Minor regional and local transmission impacts would be expected.

Under Alternative 4, power generation from the combined WVS projects would not be economically viable. There would be a $1.162 billion reduction in Net Present Value and a $27.84/MWh increase in the median Levelized Cost of Generation compared to the No Action Alternative[24]. Under Alternative 4, long-term, major, adverse effects on economic viability of power generation are anticipated.

**Table 3.12-22. Summary of Effects under Alternative 4 (ALT4).[5]**

| Metrics | No Action Alternative | ALT4 | ALT4 relative to No Action |
|---|---|---|---|
| WVS Projects 73-Year Average Generation (aMW) | 171 | 172 | +1 |
| WVS Projects Critical Water year (1937) Average Generation (aMW) | 150 | 148 | -2 |
| Loss of Load Probability (LOLP) | 6.5% | 6.5% | 0[a] |
| Resource Replacement | ——[1] | N/A[a] | N/A[a] |
| Transmission Flow Paths[3]<br>Cross Cascades South | W 6475.5<br>SP 4100.5<br>SU 5862.9 | W 6479.7<br>SP 4115.5<br>SU 5853.5 | W +4.2<br>SP +15<br>SU -9.4 |
| South of Allston | W 1183.0<br>SP 732.1<br>SU 2525.1 | W 1184.5<br>SP 735.3<br>SU 2522.4 | W +1.5<br>SP +3.2<br>SU -2.7 |
| Transmission Reliability | Same/similar to affected environment[4] | No change | No change |
| Net Present Value (median) | $225 Million | -$937 Million | -$1.162 Billion |
| Levelized Cost of Generation ($/MWh) | $26.70 | $54.54 | +$27.84 |

Note: The estimated LOLP effect, and resulting transmission and economic viability effects, rely on the best available information regarding planned coal plant retirements as of 2017.

1/ A "——" indicates an effect category that is not relevant to the No Action Alternative because it only has potential to occur as a result of implementing an Action Alternative (e.g., the need for new generation and transmission infrastructure and associated costs).

2/ No replacement resources would be needed to return the LOLP to the No Action Alternative level since this difference of 0.1 percent is within the +/-1 range of the accuracy of the model; LOLP is within the reasonable historical range of the NW Council target.

3/ The amount of loading (in MW) on the congested paths of Cross Cascades South (CCS) and South of Allston (SOA) are depicted during three seasonal cases (W= Winter Peak; SP= Spring Off-peak; SU= Summer Peak).

4/ The congested paths of Cross Cascades South (CCS) and South of Allston (SOA) remain congested. Generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages due to, especially, weather events or fires.

5/Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher. Additionally, structural cost estimates used in the analysis were at a conceptual design level with a 50% contingency. For other projects of similar size and complexity, the conceptual design cost estimates increased by 137% to 215% upon completion of the detailed design report. Post-construction, the complexity of these systems has typically resulted in further costs to improve performance. Higher implementation costs than currently estimated would result in additional reductions of the Net Present Value and increases in the levelized costs of generation.

#### *3.12.2.8.7 Alternative 4 Climate Change Impacts for Power Generation and Transmission*

Since the WVS will likely experience increasing winter time (December through March) flow volumes due to climate change generally, it is possible that projects may be able to capture some additional flow and produce incremental increases in power generation during the winter. However, higher projected temperatures are likely to result in decreased heating loads. Increases in power generation would incrementally decrease stress on existing congested paths (i.e., South of Allston and Cross Cascades South).

Lower snowpack may reduce springtime and summertime flows, as well as potentially impact refill ability. This could lead to reduced ability to generate in the and summer. Increasing air temperatures are likely to increase demand for power in the summer due to increased cooling loads. Decreases in power generation would incrementally increase stress on existing congested paths (i.e., South of Allston and Cross Cascades South).

Since flow targets are lower under Alternative 4, reservoirs could store more water during the conservation season than under the No Action Alternative. However, it is likely this stored water would be needed to meet downstream flow targets due to climate change projected increased variability in the spring, drier, hotter summer months and lower summer base flow. Due to this, reservoirs are projected to have lower water surface elevations compared to the No Action Alternative which would negatively impact power generation.

Reduced reservoir levels associated with decreased refill ability or drawdowns, combined with anticipated increases in the likelihood of extreme wildfire or weather events, would incrementally increase the risks that Cougar Dam would be unable to provide power during periods of reduced reservoir levels to the community of Blue River in the event a fire or severe weather event were to cause a transmission outage between Blue River and Thurston substations. Similarly, these conditions would incrementally increase the risks that Hills Creek Dam would be unable to provide power during periods of reduced reservoir levels to the community of Oakridge if a fire or weather event were to cause a transmission outage between Oakridge and Lookout Point Substation. These risks would be greater than the No Action Alternative and would be commensurate with the duration and timing of reduced reservoir levels.

These potential climate change impacts to hydropower are based on the climate change impacts as described in the hydrologic processes section.

#### *3.12.2.9 Alternative 5-- Preferred Alternative*

The following sections show the results for Alternative 2B, which was chosen as the preferred alternative with some changes to flow. Models were not run for the preferred alternative; some potential qualitative differences due to the flow changes are described. Otherwise, specific results are shown for Alternative 2B and should be very similar.

##### *3.12.2.9.1 Differences between Alternative 2B and Alternative 5*

At Green Peter and Foster, the minimum outflow target has shifted from 1,000 cfs under Alternative 2B to 700 cfs under Alternative 5. This could potentially lead to slightly lower generation than reported in the summary below.

At Hills Creek, the elevation reaches the top conservation storage less frequently under Alternative 5 than under Alternative 2B. Additionally, the lower minimum elevation is met more frequently. This could potentially lead to slightly lower generation than reported in the summary below.

##### *3.12.2.9.2 Changes in Power Generation*

Table 3.12-23 and Figure 3.12-13 present the generation results of the combined WVS projects for the No Action Alternative and Alternative 5 and differences by month. Overall, generation from the WVS projects would decrease from 171 aMW under the No Action Alternative, on average, over all water years, to 153 aMW under Alternative 5. This represents a decrease of 18 aMW, which is a 10.5 percent decrease in annual average generation. The change in critical water year generation from 150 aMW under the No Action Alternative to 134 aMW under Alternative 5 represents a 16- aMW (or 10.6 percent) decrease.

**Table 3.12-23. 73-Year Average Generation (Water Years 1935/36 through 2007/08) and Critical Water Year (CWY, 1937) Average Generation at the WVS Projects: Alternative 5 relative to No Action Alternative (NAA), in aMW.[1]**

| | AVG GEN NAA | AVG GEN Preferred | AVG GEN Difference | CWY GEN NAA | CWY GEN Preferred | CWY GEN Difference |
|---|---|---|---|---|---|---|
| Oct | 134 | 149 | 15 | 119 | 151 | 32 |
| Nov | 230 | 181 | -49 | 156 | 107 | -49 |
| Dec | 231 | 161 | -69 | 80 | 38 | -42 |
| Jan | 235 | -197 | -38 | 47 | 27 | -20 |
| Feb | 147 | 142 | -5 | 67 | 47 | -20 |
| Mar | 143 | 120 | -23 | 121 | 67 | -54 |
| Apr I | 177 | 143 | --34 | 188 | 158 | -30 |
| Apr II | 182 | 136 | -46 | 227 | 183 | -44 |
| May | 222 | 184 | -38 | 356 | 303 | -53 |
| Jun | 162 | 169 | 7 | 264 | 272 | 8 |
| Jul | 106 | 114 | 8 | 111 | 125 | 14 |
| Aug I | 114 | 118 | 5 | 115 | 116 | 1 |
| Aug II | 118 | 120 | 3 | 124 | 126 | 2 |
| Sep | 151 | 157 | 6 | 155 | 173 | 18 |
| **Annual Average[2]** | **171** | **153** | **-18** | **150** | **134** | **-16** |

1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

2/ The Annual Average is a weighted average to account for the different number of days in the 14 periods.

Source: HYDSIM modeling results.

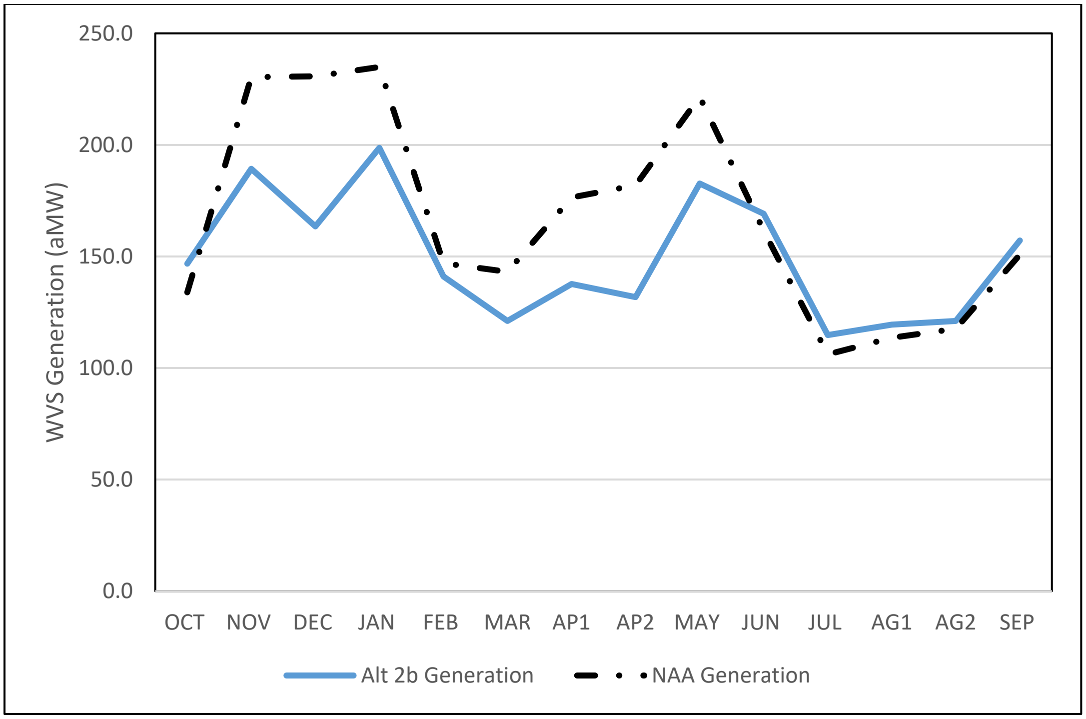


**Figure 3.12-13. Monthly Average Generation (aMW) at the WVS Projects, Alternative 2B and No Action Alternative.**

*3.12.2.9.3 Effects on Power System Reliability*

Due to the slight decrease in total hydropower generation under Alternative 2B, the LOLP would be 6.6 percent, or 0.1 percentage points greater than the LOLP in the No Action Alternative. The LOLP change from the No Action Alternative (6.5 percent) to Alternative 2B (6.6 percent) are negligible (i.e., within the +/- 1 percent range of modeling accuracy). A 6.6 percent LOLP is roughly equivalent to a one-in-fifteen year likelihood of a loss of load event or events (i.e., power shortages resulting in blackouts or emergency actions), which is the same likelihood of an event(s) as the No Action Alternative.

*3.12.2.9.4 Potential Replacement Resources and Associated Costs*

Given that the LOLP is not materially different between Alternative 5 and the No Action Alternative, the analysis finds that no replacement resources would occur under Alternative 5 to return the LOLP to the No Action Alternative level. Though greater than the NW Council's standard of five percent, the 6.6 percent LOLP under Alternative 5 is within the reasonable historical range of the NW Council target.

*3.12.2.9.5 Effects on Transmission*

Overall, changes in the patterns of WVS project generation under Alternative 5 would have moderate impacts to the transmission system due to the need to replace generation from more distant sources. The congested path of Cross Cascades South and South of Allston would see an increase of 21.9MW and 8.3MW in the Winter Peak case, respectively, and an increase of 25.1MW and 5.1MW in the Spring Off-peak case, respectively. For local impacts, generation at Hills Creek Dam would continue to be able to operate islanded (isolated) from the rest of the power system, providing power to the community of Oakridge during temporary power system outages primarily due to weather events or fires. Whereas, deep fall and spring drawdowns of the Cougar reservoir would likely compromise the ability of Cougar Dam to provide power to the community of Blue River in the event of a fire or severe weather event causing a temporary transmission outage between Blue River and Thurston substations.

Tables depicting power flows on Bonneville Transmission Network Paths under different seasonal conditions for Alternative 5 with comparison to the No Action Alternative are presented in Appendix G, Power and Transmission.

#### *3.12.2.9.6 Effects on Economic Viability of Power Generation*

Under Alternative 5, power generation from the combined WVS projects would not be economically viable. Over the 30-year study period, power operations are estimated to have a median Net Present Value of -$714 million under Alternative 2B[45]. This is an $939 million, or 417 percent, reduction in Net Present Value compared to the No Action Alternative. Across the 1,600 iterations that varied energy prices and water conditions, only 1.31 percent resulted in a positive Net Present Value. The median Levelized Cost of Generation for the combined WVS projects is estimated to rise from $26.70/MWh under the No Action Alternative to $50.81/MWh under Alternative 5, which is a $24.11, or 90 percent, increase. This is substantially greater than expected market prices and less competitive compared to other renewable resources that are expected to become more affordable in the future.

Looking at individual projects[46], Hills Creek is the only WVS project under Alternative 5 that has a positive median Net Present Value at $39 million. Its levelized cost of generation is $22.20/MWh. Hills Creek is also the only projects that has a positive Net Present Value in more than 50% of the 1600 iterations from the economic analysis. Other projects have negative median Net Present Values ranging from -$33 million (Lookout Point/Dexter) to -$354 million (Detroit/Big Cliff); levelized costs of generation ranging from $34.52/MWh (Lookout Point/Dexter) to $363.99/MWh (Cougar); and proportion of 1,600 iterations resulting in a

[45] Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher. Additionally, structural cost estimates used in the analysis were at a conceptual design level with a 50% contingency. For other projects of similar size and complexity, the conceptual design cost estimates increased by 137% to 215% upon completion of the detailed design report. Post-construction, the complexity of these systems has typically resulted in further costs to improve performance. Higher implementation costs than currently estimated would result in additional reductions of the Net Present Value and increases in the levelized costs of generation.

[46] Cougar and Hills Creek dams are operated as individual projects. Additionally, peaking dams and their respective re-regulating dams are functionally operated together as individual projects; therefore, the combined peaking/reregulating dams (Detroit/Big Cliff, Green Peter/Foster, and Lookout Point/Dexter) are treated as individual projects.

positive Net Present Value ranging from 0 percent (Cougar) to 33.63 percent (Lookout Point/Dexter).

Tables depicting 30-year Net Present Value, Percent of Iterations with a Positive Net Present Value, and Levelized Cost of Generation for WVS projects are presented in Appendix G, *Power and Transmission*.

### *3.12.2.9.7 Summary of Effects*

Table 3.12-24 presents generation, power system reliability, transmission flow paths and reliability, and economic conditions under the No Action Alternative with comparison to Alternative 5. Under Alternative 5, hydropower generation from the WVS projects would decrease by 18 aMW (roughly the amount of power consumed by 14,334 Northwest homes in a year) relative to the No Action Alternative on average under historical water conditions. The WVS projects would lose 12 aMW of firm power production under critical water conditions. Alternative 5 increases the LOLP to 6.6 percent associated with the loss in generation and no replacement resources would occur since this 0.1 percent difference relative to the No Action Alternative is within the +/-1 range of the accuracy of the model. The LOLP is within the reasonable historical range of the NW Council target. Therefore, impacts to power system reliability would be negligible.

Under Alternative 5, moderate impacts on the Cross Cascades South transmission path would be expected. There would be an increase of 25.1MW on the Cross Cascades South path. Under fall and spring deep drawdown conditions, the ability for Cougar Dam to serve load to the community of Blue River during temporary transmission outages that may occur is expected to be compromised.

Under Alternative 5, power generation from the combined WVS projects would not be economically viable. There would be an $939 million reduction in Net Present Value and a $24.11/MWh increase in the median Levelized Cost of Generation compared to the No Action Alternative[18]. Under Alternative 5, long-term, major, adverse effects on economic viability of power generation are anticipated.

**Table 3.12-24. Summary of Effects under Alternative 5 (ALT5).[5]**

| Metrics | No Action Alternative | ALT2B | ALT2B relative to No Action |
|---|---|---|---|
| WVS Projects 73-Year Average Generation (aMW) | 171 | 153 | -18 |
| WVS Projects Critical Water year (1937) Average Generation (aMW) | 150 | 136 | -12 |
| Loss of Load Probability (LOLP) | 6.5% | 6.6% | +0.1[2] |
| Resource Replacement | ——[1] | N/A[2] | N/A[2] |
| Transmission Flow Paths[3]<br>Cross Cascades South | W 6475.5<br>SP 4100.5 | W 6497.4<br>SP 4125.6 | W +21.9<br>SP +25.1 |

| **Metrics** | **No Action Alternative** | **ALT2B** | **ALT2B relative to No Action** |
|---|---|---|---|
| | SU 5862.9 | SU 5858.6 | SU -4.3 |
| South of Allston | W 1183.0<br>SP 732.1<br>SU 2525.1 | W 1191.3<br>SP 737.2<br>SU 2523.8 | W +8.3<br>SP +5.1<br>SU -1.3 |
| Transmission Reliability | Same/similar to affected environment4 | Regionally- Same/similar to NAA<br>Locally: unable to operate islanded at Cougar Dam during deep fall and spring drawdowns under certain conditions | No change regionally; comprised ability to meet local transmission services at Blue River during weather or fire related temporary outages |
| Net Present Value (median) | $225 Million | -$714 million | -$939 million |
| Levelized Cost of Generation ($/MWh) | $26.70 | $50.81 | +$24.11 |

Note: The estimated LOLP effect, and resulting transmission and economic viability effects, rely on the best available information regarding planned coal plant retirements as of 2017.

1/ A "——" indicates an effect category that is not relevant to the No Action Alternative because it only has potential to occur as a result of implementing an Action Alternative (e.g., the need for new generation and transmission infrastructure and associated costs).

2/ No replacement resources would be needed to return the LOLP to the No Action Alternative level since this difference of 0.1 percent is within the +/-1 range of the accuracy of the model; LOLP is within the reasonable historical range of the NW Council target.

3/ The amount of loading (in MW) on the congested paths of Cross Cascades South (CCS) and South of Allston (SOA) are depicted during three seasonal cases (W= Winter Peak; SP= Spring Off-peak; SU= Summer Peak).

4/The congested paths of Cross Cascades South (CCS) and South of Allston (SOA) remain congested. Generation at Hills Creek and Cougar dams would remain able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages due to, especially, weather events or fires.

5/Bonneville's share of basin-wide costs (e.g., RME) were not included in this analysis. With inclusion of those costs, the Net Present Value would be incrementally lower and the levelized costs of generation would be incrementally higher. Additionally, structural cost estimates used in the analysis were at a conceptual design level with a 50% contingency. For other projects of similar size and complexity, the conceptual design cost estimates increased by 137% to 215% upon completion of the detailed design report. Post-construction, the complexity of these systems has typically resulted in further costs to improve performance. Higher implementation costs than currently estimated would result in additional reductions of the Net Present Value and increases in the levelized costs of generation.

#### *3.12.2.9.8 Alternative 5 Climate Change Impacts for Power Generation and Transmission*

Since the WVS will likely experience increasing winter time (December through March) flow volumes due to climate change generally, it is possible that projects may be able to capture some additional flow and produce incremental increases in power generation during the winter. However, higher projected air temperatures are likely to result in decreased heating loads. Increases in power generation would incrementally decrease stress on existing congested paths (i.e., South of Allston and Cross Cascades South).

Lower snowpack may reduce springtime and summertime flows, as well as potentially impact refill ability. This could lead to reduced ability to generate power in the spring and summer. Increasing air temperatures are likely to increase demand for power in the summer due to increased cooling loads. Decreases in power generation would incrementally increase stress on existing congested paths (i.e., South of Allston and Cross Cascades South).

Climate change would affect Alternative 5 similar to the No Action Alternative with regards to hydropower. Under Alternative 5, there may be the potential to release and store more water in the spring and summer of dry years as compared to the No Action Alternative. The flow targets in Alternative 5 are lower than the current flow requirements, the reservoir may be able to store more water. However, the projects would likely have to use more of the stored water later in the season due to the projected variability in the spring months, hotter, drier summers, and lower summer base flow due to climate change.

Reservoirs in Alternative 5 sometimes drop to minimum elevation during the summer, but less often than the No Action Alternative, meaning storage levels would generally be able to augment summer flow for longer than the No Action Alternative even with projected decline in later spring and summer flows. This may alleviate some of the projected decrease in power generation in the summer from climate change than would occur under the No Action Alternative.

Reduced reservoir levels associated with decreased refill ability or drawdowns, combined with anticipated increases in the likelihood of extreme wildfire or weather events, would incrementally increase the risks that Cougar Dam would be unable to provide power during periods of reduced reservoir levels to the community of Blue River in the event a fire or severe weather event were to cause a transmission outage between Blue River and Thurston substations. Similarly, these conditions would incrementally increase the risks that Hills Creek Dam would be unable to provide power during periods of reduced reservoir levels to the community of Oakridge if a fire or weather event were to cause a transmission outage between Oakridge and Lookout Point Substation. These risks would be greater than the No Action Alternative and would be commensurate with the duration and timing of reduced reservoir levels.

These potential climate change impacts to hydropower are based on the climate change impacts as described in the hydrologic processes section

#### *3.12.2.9.9 Evaluation of Near-Term Operations Measure*

See Alternative 2A, Section 3.12.2.3.8, for description of effects due to the Near-Term Operations Measure.

## 3.13 WATER SUPPLY

Water is critical for the sustenance and continued growth of the Willamette Valley, which is home to more than 70% of the population of Oregon. The Oregon Water Resources Department is the state entity responsible for managing water in the state, including issuing water rights to use the water, be it for consumptive uses, instream purposes, or storing water for future use. Water users in the Willamette Basin rely on natural river flow, groundwater, and stored water released from reservoirs to satisfy state issued water rights for many types of uses. The two main consumptive uses of water from rivers are municipal and industrial (M&I) water supply and agricultural irrigation. This section focuses on effects to existing natural flow water rights for M&I and irrigation as well as the effects to the use of stored water via the storage allocations as discussed in Section 1.8.2 and detailed in the Willamette Basin Review Feasibility Study Report and Environmental Assessment (WBR), authorized by Congress in 2020 (USACE 2019a).

### 3.13.1 Affected Environment

Agricultural irrigation and municipal and industrial (M&I) water supply were original authorized purposes of the Willamette Valley project.

The study area is defined broadly as the geographic boundaries of the Willamette River Basin (WRB). As noted in Chapter 1, the WRB is located entirely within the state of Oregon, beginning south of Cottage Grove, and extending approximately 187 miles to the north where the Willamette River flows into the Columbia River. For effects to water supply resulting from changes to operations of the Corps' Willamette Valley System of 13 reservoirs, the study area was further refined to include the Willamette River and its tributaries with a Corps' project.

#### *3.13.1.1 Irrigation Water Supply*

The expansion of agricultural irrigation (AI) in the Willamette River Basin was slow until the 1940s. There were about 1,000 irrigated acres of farmland in the WRB in 1911 and 3,000 irrigated acres in 1920. By 1930, the basin contained 5,000 irrigated acres, which increased to 27,000 acres by 1940. A dramatic increase in the number of irrigated acres occurred in the WRB during the postwar decades. In 1964, approximately 194,000 acres were irrigated in the basin (OWRB, 1967). Irrigated acreage increased to about 300,000 acres by 2007, while irrigated acreage reported for 2012 decreased to a level of 250,000 acres (2007 and 2012 reported values from the U.S. Department of Agriculture, Census of Agriculture).

AI was recognized as a project purpose in the Willamette Valley System (WVS) authorizing legislation, and irrigation was thought to be the largest future use of WVS stored water. However, agricultural irrigation water demand in the Willamette Valley has not grown at the rate foreseen in the authorizing documents. Water use and conservation practices employed by the agricultural community also have changed since the WVS was authorized. WVS conservation storage totals approximately 1,590,000 acre-feet. Of this total, only 82,815 acre-feet of stored water (less than 5 percent of the conservation storage volume) is contracted through Reclamation for irrigation use on 43,857 acres. It should be noted that the vast majority of AI is not reliant on Reclamation water service contracts and withdraws water from streams through live flow water rights. At the current low level of use for water service contracts it is typically not necessary for the Corps to increase releases above the minimum flows to meet current contract requirements. The Corps does increase releases at Detroit Dam on the North Santiam River and Fern Ridge Dam on the Long Tom River to satisfy Reclamation's water service contracts.

Oregon's 2015 Statewide Long Term Water Demand Forecast provided a 2015 estimate of 605,700 acre-feet of water per year diverted for AI use within the Willamette River basin, and an estimate of 708,400 acre-feet of water per year by the year 2050 under hotter-drier conditions (a 35-year increase of 102,700 acre-feet of water per year) (OWRD 2015). This study looked only at the amount of water that may be needed under a future climate scenario for existing lands currently covered by irrigation water rights and did not include irrigation use new lands brought into agricultural production.

Irrigation water rights in Oregon identify a season of use, a rate, and a duty of water, which vary by location within the state. The season is the period of the year in which the right can be exercised, which typically corresponds to the growing season and may be extended if requested by the Oregon Department of Agriculture, as outlined in Oregon Revised Statutes (ORS) 537.385. The rate is the maximum amount of water that may be diverted or pumped, which is normally expressed in cfs. Duty is the volume of water that can be applied over the course of the season associated with the water right, which is normally expressed in acre-feet of water applied per acre. The maximum rate cannot typically be sustained on a full-time basis without exceeding the duty; from a practical water-use accounting standpoint, few water rights holders measure their rates, or their duties. All AI water service contracts, as of July 2008, that Reclamation issues from WVS releases include a requirement for flow metering, or measuring.

Based on the forecasted demand for stored water for agricultural irrigation in Corps' affected river reaches as detailed in the WBR, a total of 327,650 acre-feet was reallocated to the specific use of irrigation in the Water Resources Development Act of 2020 (WRDA) (USACE 2019a).

#### *3.13.1.2 Municipal and Industrial Water Supply*

The Willamette River and its tributaries are a major source of water for municipal and industrial needs. As population increases throughout the basin, M&I system needs increase – putting pressure on existing water supplies. To date, M&I systems rely on natural streamflow and groundwater wells in the Willamette Basin, though population growth is leading to a demand for water that exceeds existing supplies for many M&I systems throughout the basin. This need was one of the factors that led to the Willamette Basin Review Feasibility Study project, which resulted in a total of 159,750 acre-feet of conservation storage reallocated to the purpose of municipal and industrial water supply. To date, there are no agreements for using storage from any of the Willamette Project reservoirs for M&I water supply, but interest is significant among water suppliers in the Willamette Basin.

M&I systems must fully incorporate future population growth and peak season water supply demand in their long-term planning. As a result, M&I systems apply for water rights that are in excess of water presently needed so that an adequate supply would be ensured when sufficient numbers of ratepayers live in a community to justify and pay for the construction work on new diversion, conveyance, and treatment facilities. M&I systems are almost never in a position to complete full build-out of their water systems when they apply for a permit, as they lack the immediate need and ratepayer support. Still, the core mission for every M&I supplier is to secure a safe, adequate, and reliable water supply to meet current and future demand. By its nature, then, municipal water supply planning dictates identification of water supplies to meet projected needs decades into the future.

Municipalities are often given preferential treatment under the Oregon water rights system because of the public safety component of municipal water use, which is called the "Growing Communities Doctrine." The following are the components of municipal water use preferences in Oregon, which make up the Growing Communities Doctrine:

- M&I systems are not required to initiate construction of surface water diversion works within one year of being issued a water right permit (systems have up to 20 years to initiate construction plus an opportunity for extension); (FN: ORS 537.230);
- If the water right permit is to store water for municipal use, M&I systems have ten years to begin and complete construction of diversion or storage works; however, systems may apply for extensions in ten-year increments; (FN: ORS 537.248);
- An M&I system can certify a portion of its water right permit without cancellation of the remaining portion of water authorized to be diverted under the right. To do so, the municipality must "perfect", or use, at least 25 percent of the amount authorized on the permit; (FN: ORS 537.260(4));
- An M&I system water right generally is not subject to forfeiture. Although a water right that is unused for five consecutive years is presumed forfeited, the presumption is overcome by showing that the use was for a municipal purpose; (FN: ORS 540.610(2)(a));
- Water rights issued to M&I systems may be used on lands to which the right is not appurtenant, under certain circumstances; and
- Municipal uses for human consumption may take preference over other types of senior instream water rights established through the permitting process (as opposed to conversion or acquisition) if Oregon Water Resources Department (OWRD) determines that this would be in the public interest.

Taken together, this means that there are undeveloped M&I system water rights throughout the basin because use and population for some M&I systems have not yet grown to the extent reflected in their existing water right permits. It is important to note that undeveloped M&I system uses are considered by OWRD when water availability calculations are conducted.

### *3.13.1.3 Summary of Water Use in the Willamette River Basin*

The following sections detail the water rights for municipal and industrial water supply and agricultural irrigation in the Willamette sub-basins with Corps dams and also on the mainstem of the Willamette River.

#### *3.13.1.3.1 Water Rights*

**Error! Reference source not found.**1 and Table 3.13-22 below list the number of diversions and permitted flow of water for withdrawals in tributaries with a Corps dam and reservoir and on the mainstem Willamette River.

The Coast Fork of the Willamette River is a small sub-basin with relatively small levels of consumptive use for M&I water supply and AI.

The Middle Fork of the Willamette River has a moderate level of demand for irrigation water and a small level of demand for M&I water supply. Fall Creek does not have any M&I diversions but does have irrigation withdrawals.

The McKenzie River has the second highest number of M&I and irrigation diversions of the sub-basins but only a third and a quarter, respectively, of the number on the mainstem Willamette River.

The Long Tom River has a very small number of withdrawals for M&I water supply but has a very high number of irrigation diversions relative to the size of the river. The sub-basin is heavily agricultural focused.

The Santiam Basin, comprising the North and South Rivers and the relatively short reach of the Santiam River, is an important area for agricultural use within the Willamette River Basin. The Santiam Basin is second only to the mainstem Willamette River for both M&I and agricultural water use. Large irrigation districts, including the Santiam Water Control District, which provides water to not only irrigation customers, but numerous municipal entities as well, are some of the largest users of water in the Santiam Basin. Irrigators in the Santiam Basin use stored water released from both Detroit and Green Peter dams.

The City of Salem uses water withdrawn from the North Santiam River at Geren Island, near the town of Stayton, as its primary source for drinking water to its citizens as well as industrial customers. The drinking water treatment plant on Geren Island requires a minimum flow in the river of 750 cfs to be operational.

The majority of water withdrawals in the Willamette Basin occurs from the mainstem of the Willamette River, from just south of the City of Eugene to the confluence with the Columbia River. The highest level of use occurs below Salem, in the Portland metropolitan area, home to the majority of the Willamette Basin population.

**Table 3.13-1 . Surface Water Points of Diversion in Select Tributaries to and on the Mainstem Willamette River (OWRD WRIS, July 2021)**

| Reach | Municipal Surface Water Diversions | Industrial Surface Water Diversions | Irrigation Surface Water Diversions |
|---|---|---|---|
| Coast Fork Willamette River | 26 | 15 | 169 |
| Row River | 7 | 0 | 38 |
| Middle Fork Willamette River | 4 | 8 | 71 |
| Fall Creek | 0 | 0 | 27 |
| McKenzie River | 30 | 19 | 309 |
| Long Tom River | 4 | 2 | 250 |
| North Santiam River | 22 | 23 | 359 |
| South Santiam River | 20 | 18 | 205 |
| Santiam River | 7 | 1 | 181 |
| Willamette River | 92 | 53 | 1277 |

**Table 3.13-2. Summary of Water Use in Select Tributaries to the Willamette River (OWRD WRIS, July 2021)**

| Reach | Municipal Surface Water Diversions (cfs) | Industrial Surface Water Diversions (cfs) | Irrigation Surface Water Diversions (cfs) |
|---|---|---|---|
| Coast Fork Willamette River | 3.91 | 4.53 | 94.16 |
| Row River | 10.92 | 0 | 5.23 |
| Middle Fork Willamette River | 6.95 | 4.65 | 13.46 |
| Fall Creek | 0 | 0 | 8.25 |
| McKenzie River | 409.56 | 198.48 | 102.42 |
| Long Tom River | 1.49 | 0.36 | 181.43 |
| North Santiam River | 68.92 | 15.11 | 192.55 |
| South Santiam River | 218.11 | 21.45 | 67.34 |
| Santiam River | 6.51 | 0.67 | 137.51 |

#### *3.13.1.3.2 Forecasted Demand for Stored Water*

The WBR, completed in 2019, estimated the need for water stored in the Corps' reservoirs to supply future M&I water supply and irrigation needs. These demands were spread across the sub-basins, but with a vast majority on the mainstem Willamette River. Table 3.13-3 below lists the distribution of estimated demands for stored water for M&I and irrigation needs by the year 2050.

**Table 3.13-3. Estimated New Demands (annual) for Stored Water by the Year 2050**

| Reach | Waterway | Municipal and Industrial Demand for Stored Water (af) | Agricultural Irrigation Demand for Stored Water (af) |
|---|---|---|---|
| 1 | Willamette River, downstream of Santiam River confluence | 65,358 | 69,483 |
| 2 | Santiam River | 387 | 3,666 |
| 3 | North Santiam River | 1,490 | 5,124 |
| 4 | South Santiam River | 552 | 5,963 |
| 5 | Willamette River, between the Santiam and Long Tom River confluences | 2,018 | 6,433 |
| 6 | Long Tom River | 1 | 6,389 |
| 7 | Willamette River, between the Long Tom and McKenzie River confluences | 808 | 3,870 |
| 8 | McKenzie River | 1,867 | 2,740 |
| 9 | Willamette River, between McKenzie and Coast Fork/Middle Fork confluences | 795 | 29 |
| 10 | Middle Fork Willamette River, below the Fall Creek confluence | 7 | 1,127 |
| 11 | Middle Fork Willamette River | 1 | 4,819 |
| 12 | Fall Creek | 0 | 84 |
| 13 | Coast Fork, below confluence with Row River | 0 | 730 |
| 14 | Row River | 6 | 52 |
| 15 | Coast Fork, above confluence with Row River | 0 | 11 |
| Total | | 73,920 | 110,520 |

### 3.13.2 Methodology

The following section describes the evaluation criteria for determining effects to M&I water supply and irrigation users.

**All comparisons of effects for each action alternative are in comparison to the NAA unless stated otherwise.**

**Table 3.13-4. Evaluation Criteria for Potential Effects for Water Supply**

| Effect Scale | Criteria (Live Flow Water Rights) | Criteria (Storage Allocations and Stored Water) (1) |
|---|---|---|
| Negligible | Use of water for M&I water supply or irrigation would not be affected because changes to downstream flows would be either nondetectable or, if detected, would have effects that would be slight and localized to a portion of a stream. Effects would be of very limited duration and would not require additional consideration. | More than 90% of available storage space is filled, or more than 1,431,000 acre-feet of water, at least 75% of the time; was stored by May 20. |
| Minor | Changes to downstream flows would be measurable, although the changes would be small and limited to one or two tributaries. The duration of effects would be of limited annual duration, occurring mainly in the spring each year. | More than 75 - 89% of available storage space is filled, or more than 1,192,500 acre-feet but less than 1,431,000 acre-feet of water, at least 75% of the time; was stored by May 20. |
| Moderate | Changes to downstream flows would be measurable and occur on more than two tributaries. The duration of flow changes would occur annually for more than one continuous month during the summer low flow period. | More than 60 - 74% of available storage space is filled, or more than 954,000 acre-feet but less than 1,192,500 acre-feet of water, at least 75% of the time; was stored by May 20. |
| Major | Changes to downstream flows would be measurable and would extend for more than a month during the summer low flow period. | Less than 60% of available storage space is filled, or less than 954,000 acre-feet of water, at least 75% of the time; was stored by May 20. |

[1]Though the model results indicate an increase or decrease to peak May storage volumes, the actual effects to stored water users are unknown at this time because the annual management process in dry years has not been established, as required by WBR BiOp RPA.

Effects to water supply would be both direct and indirect. Based on the recommendation in the WBR Chief's Report, Congress reallocated the conservation storage space in the WVS reservoirs from all joint-use storage to three specific authorized purposes – fish and wildlife (69%), agricultural irrigation (21%), and municipal and industrial water supply (10%) (USACE 2019a). Alternatives that contain measures that intentionally modify operations of the reservoirs such that the ability to refill the conservation storage space is diminished have a direct effect on water supply users relying on the stored water as the water would not be available for them to call on to be released.

Changes to the amount of water released from the dam have a direct effect on downstream water users.

Effects to water supply (M&I and AI) from all the alternatives would be long term. There could be short-term effects to water supply from construction activities associated with structural measures, or where construction or modification of existing facilities is required for an operational measure. These effects will be addressed in site-specific NEPA and are not included in the analysis below.

Beneficial effects result from an increase of water stored in the reservoirs or increases in summer flows when compared to the No Action Alternative (NAA).

Adverse effects result when there is a decrease in the amount of water stored in the reservoirs or a decrease in summer flows when compared to the NAA.

### 3.13.3 Environmental Consequences

The WVS Draft PEIS alternatives include structural and operational measures for fish passage and temperature management and changes to flow regimes downstream of Corps' dams. Structural measures for fish passage and temperature management would not change the flow regimes or ability to refill the reservoirs and would therefore not affect water supply in the long term. Short term and temporary affects due to construction activities would be addressed in site specific NEPA and are not addressed here. Operational fish passage measures may affect the ability to refill the conservation pools within the reservoir and therefore may affect water supply. Minimum flow regimes that change river flows downstream of the Corps' dams may affect downstream water supply users. The water supply analysis below used ResSim modeled flow data to qualitatively evaluate physical effects to water supply.

The Corps analyzed the total maximum volume of water stored in the WVS reservoirs between May 10 – 20 that is expected to occur 75% of the time (P25 on the storage charts shown below) to evaluate effects to storage allocations and use of stored water for consumptive use. This stored water would be released to meet M&I and irrigation consumptive uses and instream to support fish and wildlife. Dexter and Big Cliff dams are re-regulation dams and do not have conservation storage; therefore, these two reservoirs are not considered in this evaluation or in the total volume of stored water.

Assessing effects to live flow water rights on a programmatic level is challenging. The Corps compared the level of flow at the control points on Corps effected tributaries and on the mainstem Willamette River between the NAA and the action alternatives to determine an expected level of impact to these users.

The WBR Biological Opinion (BiOp) Reasonable and Prudent Alternative (RPA) Measure 2 includes a cap on new water storage for M&I use of a total of 11,000 acre-feet and no agreements in the Santiam Basin until National Marine Fisheries Services (NMFS) issues its written agreement to the Corps that instream water rights are in place and providing sufficient protection to flows intended to benefit fish. The Corps determined it is reasonable to assume actions necessary to protect instream flows for fish with instream water rights would occur and this cap would be lifted into the future; therefore, the 2050 M&I demand due to future M&I deficits and new self-supplied industrial (SSI) uses of water, totaling 73,300 ac-ft, for both the NAA and the action alternatives was used for modeling purposes.

While the WBR evaluated effects from the full irrigation allocation volume of 327,650 acre-feet, the WBR BiOp did not address the existing cap on Bureau of Reclamation (BOR) irrigation water service contracts of 95,000 acre-feet. Therefore, the NAA assumes the level of water service contracts of 82,815 acre-feet. It is reasonable to assume that demand for water service contracts for irrigation will increase within the next 30 years. The BOR concurred with using the 2050 increase in demand for stored water for irrigation use calculated as part of the WBR study for modeling effects of increased irrigation use in the system, an additional 110,500 acre-feet plus an additional 62,050 for existing users whose water right would be junior to instream water rights and would therefore need a backup water source. The total agricultural irrigation uses of stored water considered in this analysis is 255,385 acre-feet.

The ResSim model releases the full 2050 demand volumes when there is water above the minimum conservation elevations. Due to limitations with ResSim, the withdrawals and return flows are always active, even when reservoirs are below minimum conservation elevation, and no stored water is released to satisfy the withdrawals. WBR BiOp RPA Measures 3 and 4 require the USACE to determine on an annual basis the amount of water that will be available to satisfy M&I storage agreements and irrigation water service contracts. In dry years when total system storage (amount of water stored in the WVS reservoirs) is low, water may not be available to meet all the stored water demands. This determination will be made based on realized hydrology. ResSim limitations precluded developing complex rules regarding when stored water would be available for consumptive uses and when it would not; therefore, the ResSim model results do not include reductions in use of stored water for M&I and irrigation. Though the model results indicate an increase or decrease to peak May storage volumes, the actual effects to stored water users are unknown at this time because the annual management process in dry years has not been established, as required by RPAs 3 and 4 in the WBR BiOp.

Site-specific project details for each construction measure will be determined during the preconstruction engineering and design phase. While general, qualitative effects from construction are discussed below on a programmatic level, the more detailed, site-specific analysis will be included in future, tiered EAs or EISs.

The geographic scope of effects to water supply can occur at both the local level within a sub-basin and at the larger Willamette River Basin level as the majority of users are on the mainstem Willamette River, downstream of the Corps' projects.

The Coast Fork and Long Tom sub-basins are not discussed in the analysis below as the hydrologic analysis in Section 3.2.3 showed no difference between the NAA and any of the alternatives. Effects to downstream flows in the North Santiam and McKenzie are noted in certain alternatives due to the extent of the operations proposed in those alternatives.

**Table 3.13-5.** **Summary of Effects for Water Supply and Storage Allocations**

| | **No Action Alternative** | **Alternative 1** | **Alternative 2A** | **Alternative 2B** | **Alternative 3A** | **Alternative 3B** | **Alternative 4** | **Alternative 5** |
|---|---|---|---|---|---|---|---|---|
| North Santiam | N/A | Minor adverse | Minor adverse | Minor adverse | Major adverse | Minor adverse | Minor adverse | Minor adverse |
| South Santiam | N/A | Minor adverse | Negligible | Negligible | Negligible | Major adverse | Negligible | Negligible |
| Santiam | N/A | Minor adverse | Negligible | Negligible | Negligible | Minor adverse | Negligible | Negligible |
| Long Tom River | N/A | None | None | None | None | None | None | None |
| McKenzie | N/A | Negligible | Negligible | Negligible | Negligible | Negligible | Negligible | Negligible |
| Middle Fork Willamette | N/A | Negligible | Negligible | Negligible | Moderate adverse | Minor adverse | Negligible | Negligible |
| Coast Fork Willamette | N/A | Negligible | Negligible | Negligible | Negligible | Negligible | Negligible | Negligible |
| Mainstem Willamette | N/A | Minor beneficial | Negligible | Negligible | Negligible | Negligible | Negligible | Negligible |
| Storage Allocations (1) | Moderate beneficial | Moderate beneficial | Minor beneficial | Minor adverse | Major adverse | Major adverse | Minor beneficial | Minor adverse |

(1) These are based on modeled results. The annual management plan for use of available water has not yet been developed per the WBR BiOp RPA.

#### *3.13.3.1 No Action Alternative*

The NAA includes new releases of stored water from the reservoirs and withdrawals in downstream reaches for M&I purposes to satisfy new water storage agreements from the M&I allocation. The volume of M&I water storage agreements was assumed to be 73,300 acre-feet of storage (the 2050 level of demand from the WBR).

The NAA continues the current water management objectives, which attempt to manage reservoir levels to balance the needs of all authorized purposes. Water would be released from the reservoirs to satisfy demands of stored water for municipal and industrial uses at the 2050 demand level and existing, as of April 2019, irrigation water service contracts. See Appendix X for further details. Figure 3.13-1 shows that 75% of the time, the maximum total volume of water stored in the WVS reservoirs would be at least 1.3 million acre-feet, resulting in enough stored water to meet the M&I and irrigation demands in most years. Stored water would not be available to meet all M&I storage agreements and irrigation water service contracts in the driest years. The amount available would be determined on an annual basis based on realized storage volumes across the system.

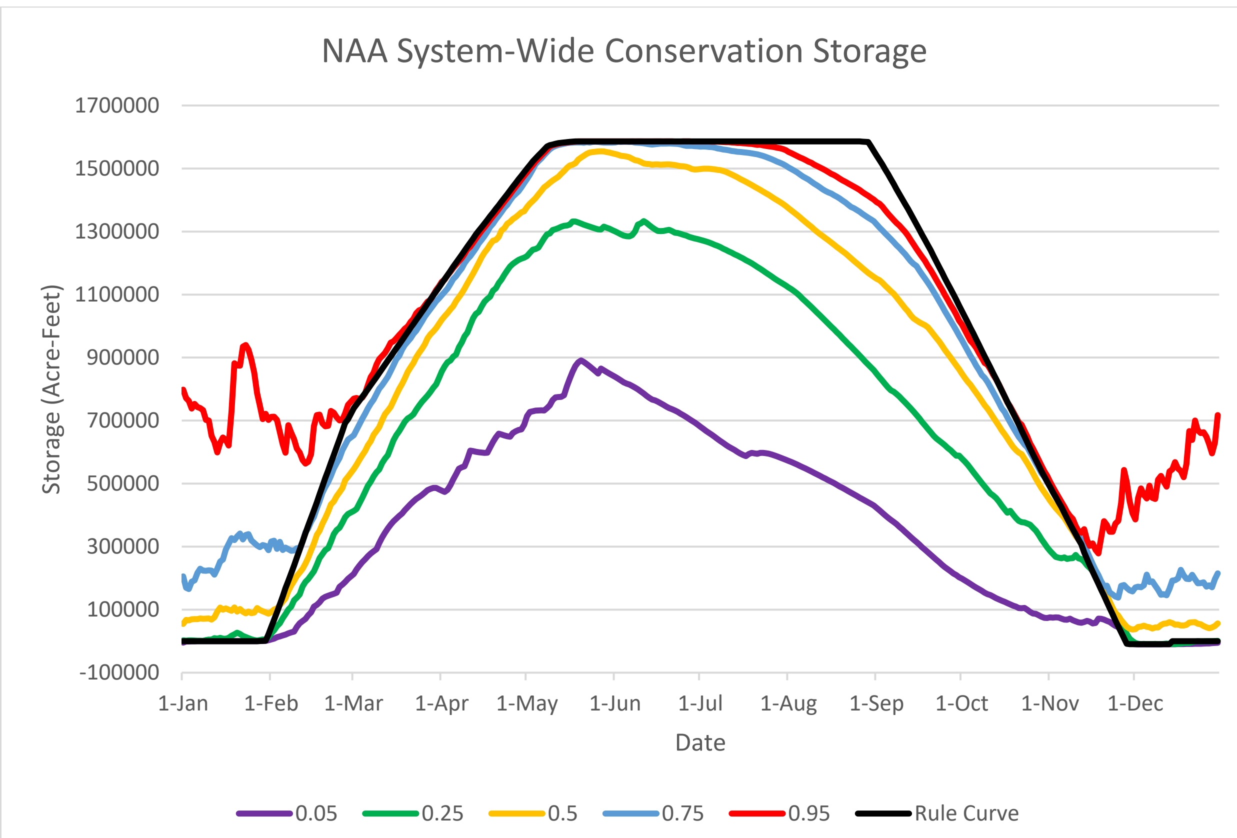


**Figure 3.13-1. System-Wide Conservation Storage Non-Exceedances Under the NAA**

Flows downstream of the WVS dams would continue to support existing water rights in the same frequency as they do today. Not all live flow water rights are fully met in all years and in all months under existing conditions and this would continue under the NAA due to hydrologic conditions beyond the control of the USACE. Figure 3.13-2 shows the modeled flow at Salem for the NAA, which includes increased releases of stored water to satisfy water storage agreements of 73,300 acre-feet, downstream withdrawals, and return flow. Under the NAA conditions, the 2008 BiOp flow target would not be met in all years, which could require a reduction in use of stored water under the storage agreements. As each individual year is different and not reflected in the flow charts, reduction of the use of stored water was not included in the ResSim modeling. Stored water would be available to satisfy M&I water storage agreements at least 80% of the time.

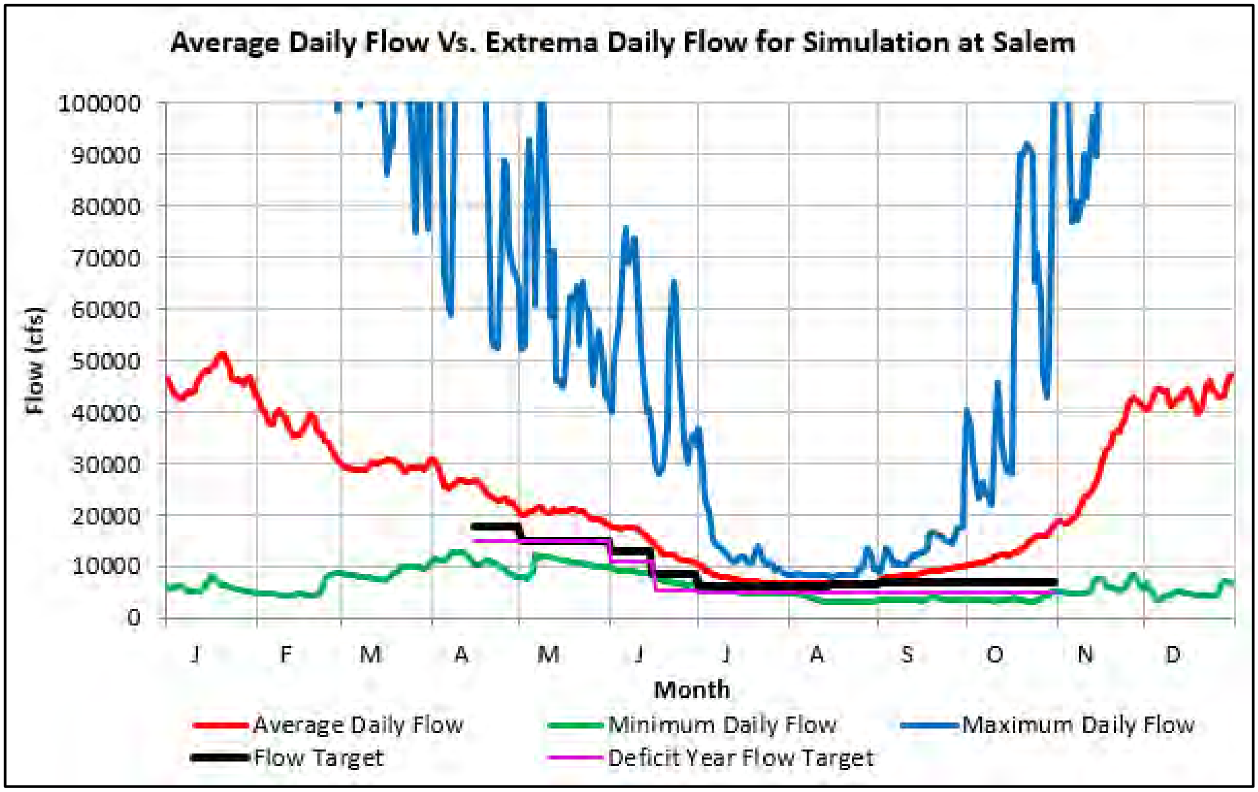


**Figure 3.13-2. Average Daily Flow, Minimum Flow, and Maximum Flow Under the NAA**

Effects from the NAA to water supply would be moderately beneficial and **long term** due to newly accessible source of stored water for M&I uses. Effects would be realized basin-wide.

### *3.13.3.1.1 Climate Change*

Water supply, both from water stored in Corps' reservoirs and from natural river flow, may be adversely affected in the future under climate change induced hydrology. Climate change may result in less reliable refill of the reservoirs and drafting earlier to minimum conservation elevations to support downstream minimum flow targets. Decreased summer baseflows would also adversely affect water users as there may not be adequate water in the rivers to satisfy existing water rights. Climate change would have an adverse effect to M&I water supply and irrigation.

#### *3.13.3.2 Alternative 1 – Project Storage Alternative*

Alternative 1 is a storage based alternative that structural downstream fish passage measures and lower minimum flow targets compared to the NAA, particularly in the spring, resulting in increased system-wide conservation storage.

##### *3.13.3.2.1 System-wide Storage*

Figure 3.13-3 shows that peak conservation storage would increase by 168,000 acre-feet in the driest year compared to the NAA, resulting in a moderate beneficial effect to system-wide storage allocations and the municipal and industrial water supply and irrigation users relying on stored water. Stored water would still not be available to meet all M&I storage agreements and irrigation water service contracts in the driest years, but to a lesser extent than in the NAA. The amount available would be determined on an annual basis based on realized storage volumes across the system.

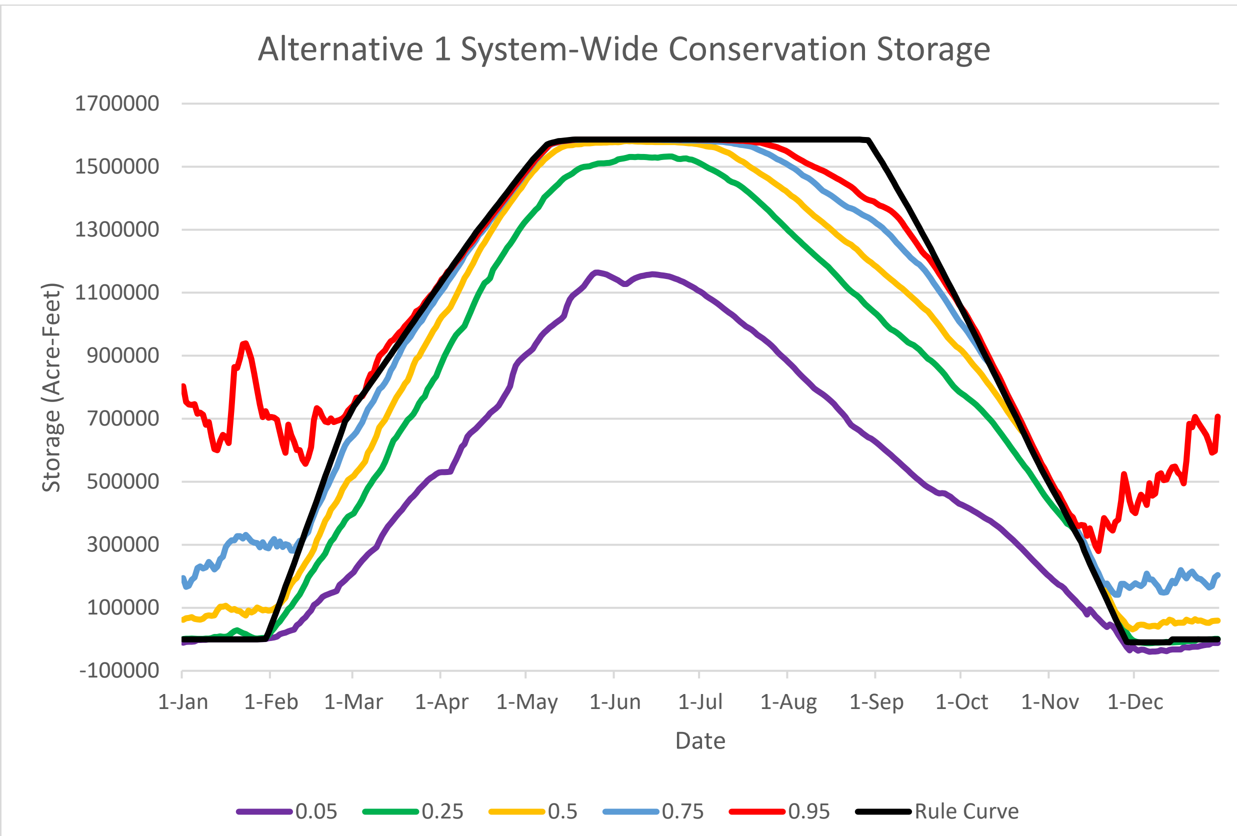


**Figure 3.13-3. System-Wide Conservation Storage Non-Exceedances Under Alternative 1**

##### *3.13.3.2.2 River Flows*

**North Santiam**

Operations affecting water supply in the North Santiam Basin include releasing flow according to the original House Document 531 flow regimes, which are less than the 2008 BiOp flow targets used currently and under the NAA.

Flow at Mehama, a key indicator for water supply users on the North Santiam, is lower in the spring as compared to the NAA, reflecting the lower spring target flows compared to the NAA. Flows drop close to 1000 cfs during parts of the spring and summer during the driest years, resulting in Detroit Reservoir filling higher than in the NAA. The reservoir would reach minimum conservation pool later in the year, following the rule curve. Real time water management of the reservoir would be capable of managing flows in the North Santiam River, as to result in only a minor adverse effect to users relative to existing conditions. This effect would be local and occur only in drier years.

**South Santiam**

Operations affecting water supply in the South Santiam Basin include releasing flow according to the original House Document 531 flow regimes.

Flows at Waterloo on the South Santiam are lower than the NAA from mid-March through June in drier years, but nearly equal during the summer most years. As the flows are lower during the spring in drier years, Alternative 1 would have a minor adverse effect on water supply in the South Santiam River.

**Santiam**

Flows at Jefferson on the Santiam, downstream of the confluence of the North and South Santiam Rivers, are lower than the NAA from mid-March through June and again in September in dry years, and nearly equal in the summer and all years. As the flows are lower during a portion of the spring and summer, but only in dry years, Alternative 1 would have a minor adverse effect on water supply in the Santiam River.

**Long Tom River**

There would be no effect to M&I water supply or irrigation from the alternative, as there are no operational changes proposed at Fern Ridge Dam that would effect outflow and the reservoir is not used to support mainstem flow targets.

**McKenzie River**

Operations affecting water supply in the McKenzie Basin include releasing flow according to the original House Document 531 flow regimes.

Flows at Vida on the McKenzie River are lower than the NAA from April through mid-June but slightly higher mid-June through September in the dry years. As the flows are lower during a portion of the spring but higher during critical summer months in dry years, Alternative 1 would have a negligible effect on water supply in the McKenzie River.

**Middle Fork of the Willamette River**

Operations affecting water supply in the Middle Fork Willamette Basin include releasing flow according to the original House Document 531 flow regimes.

Flows at Jasper on the Middle Fork Willamette River, downstream of Hills Creek, Lookout Point, and Fall Creek reservoirs, are lower than the NAA from April through mid-June about 50% of the time, but higher than the NAA during the summer months. As the flows are only lower during a portion of the spring but higher during later summer, Alternative 1 would have a negligible effect on water supply in the Middle Fork Willamette River.

**Coast Fork of the Willamette River and Row River**

Operations affecting water supply in the Coast Fork Willamette Basin include releasing flow according to the original House Document 531 flow regimes.

Flows at Goshen on the Coast Fork Willamette River, downstream of Dorena and Cottage Grove reservoirs, are only lower than the NAA from April through mid-June in the driest years. As the flows are only lower during a portion of the spring and only in drier years, Alternative 1 would have a negligible effect on water supply in the Coast Fork Willamette River.

**Mainstem Willamette River**

Operations affecting water supply on the mainstem Willamette River include releasing flow according to the original House Document 531 flow regimes.

Flows at Harrisburg on the Willamette River, downstream of the McKenzie River confluence, are lower than the NAA from April through mid-June about 25% of the time, but higher or equal to the NAA during the summer months. As the flows are only lower during a portion of the spring, still staying above 4000 cfs, and only in the drier years, Alternative 1 would have a negligible effect on water supply in the Willamette River above Harrisburg.

Flows at Albany on the Willamette River, upstream of the Santiam River confluence, are lower than the NAA from April through mid-June about 25% of the time, but higher than in the NAA during the summer months. As are higher during the summer months when water supplies are often at critical limits, Alternative 1 would have a minor beneficial effect on water supply in the Willamette River above and immediately downstream of Albany.

Flows at Salem on the Willamette River, downstream of the Santiam River confluence, are lower than the NAA from April through mid-June about 25% of the time, but higher or equal to the NAA during the summer months. As are higher during the summer months when water supplies are often at critical limits, Alternative 1 would have a minor beneficial effect on water supply in the Willamette River near and downstream of Salem.

Overall, Alternative 1 would have a minor adverse effect on water supply in the Santiam Basin, negligible effect on water supply on the McKenzie, Middle Fork, and Coast Fork Willamette, and minor beneficial effect on the mainstem Willamette River. This effect would be long term.

###### *3.13.3.2.3 Climate Change*

Water supply, both from water stored in Corps' reservoirs and from natural river flow, may be adversely affected in the future under climate change induced hydrology. Climate change may result in less reliable refill of the reservoirs and drafting earlier to minimum conservation elevations to support downstream minimum flow targets, but to a lesser degree than in the NAA because the reservoirs would generally retain more water later in the season. Therefore, the likelihood of climate changes constraining stored water supply would be slightly diminished under this Alternative compared to the NAA. Natural river flow in the summer would likely decrease due to climate change and would adversely affect water users as there may not be adequate water in the rivers to satisfy existing live flow water rights.

#### ***3.13.3.3 Alternative 2A - Hybrid Alternative***

Alternative 2A combines structural and operational fish passage measures and includes integrated habitat and temperature minimum tributary flow targets, and reduced mainstem targets. These flow targets vary throughout the year and are dependent on the level of the reservoir relative to the rule curve.

###### *3.13.3.3.1 System Storage*

Figure 3.13-4. System-Wide Conservation Storage Non-Exceedances Under Alternative 2A shows that under Alternative 2A peak conservation storage would increase by 122,000 acre-feet in the dry years, resulting in a minor beneficial effect to system-wide storage allocations and the municipal and industrial water supply and irrigation users of the conservation storage. Stored water would still not be available to meet all M&I storage agreements and irrigation water service contracts in the driest years, but to a lesser extent than in the NAA. The amount available would be determined on an annual basis based on realized storage volumes across the system.

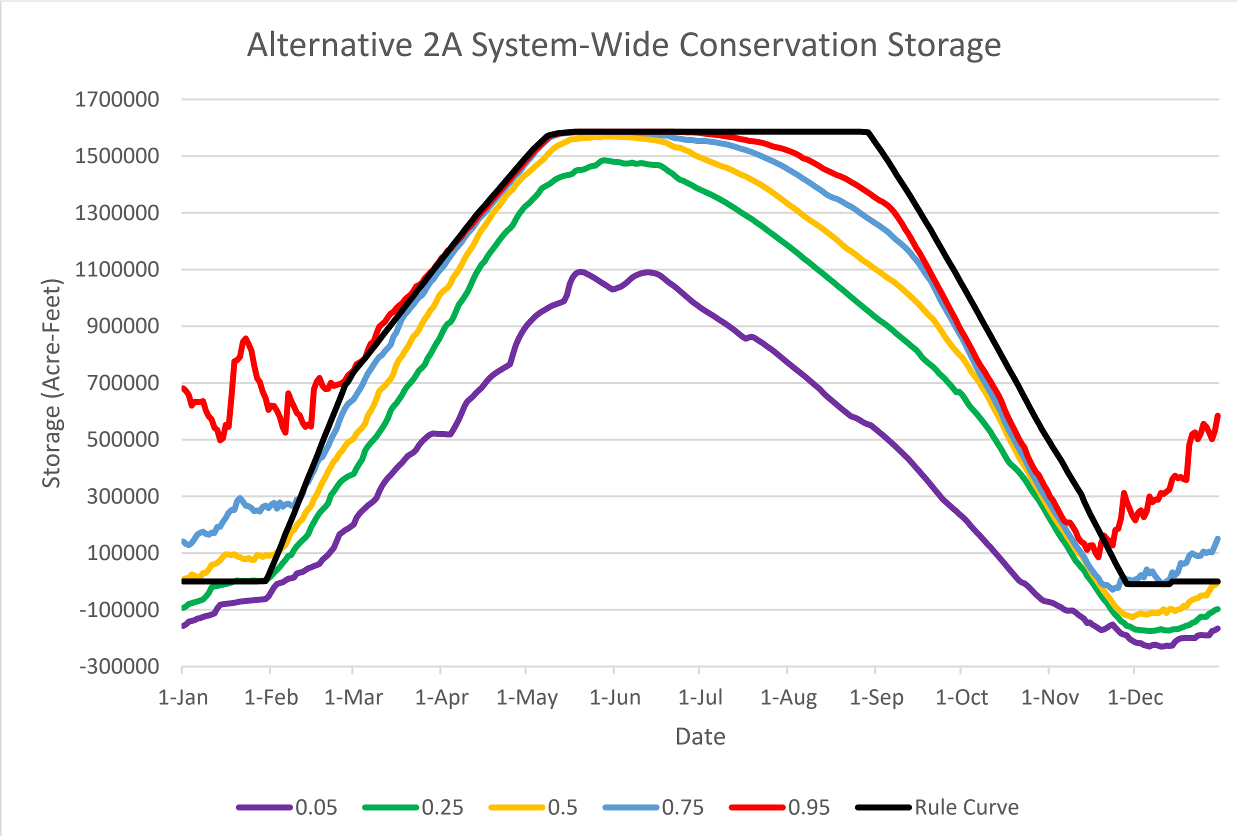


**Figure 3.13-4. System-Wide Conservation Storage Non-Exceedances Under Alternative 2A**

#### *3.13.3.3.2 River Flows*

**North Santiam**

Operations affecting water supply in the North Santiam Basin include releasing water for the integrated temperature and habitat flow regime and augmenting these flows with water from the power pool, as necessary.

Flow at Mehama, a key indicator for water supply users on the North Santiam, is slightly lower in the spring and late summer, dropping close to 1000 cfs during the late summer during the driest years, as compared to the NAA, reflecting the lower spring target flows from Detroit as compared to the NAA. Detroit Reservoir fills higher in these years and would reach minimum conservation pool later in the year, following the rule curve. Real time water management of the reservoir would be capable of managing flows in the North Santiam River, as to result in only a minor adverse effect to users relative to the NAA. This effect would be local and occur only in the driest years.

**South Santiam**

Operations affecting water supply in the South Santiam Basin include releasing water for the integrated temperature and habitat flow regime, augmenting these flows with water from the power pool, as necessary, and a fall draw down operation for fish passage.

Flows at Waterloo on the South Santiam are lower than the NAA from mid-March to early-June in the driest years, but higher in fall in all years due to the fall drawdown operation at Green Peter Dam, as indicated in Appendix B, Figure B-165. As the flows are only lower during a portion of the spring and only in the driest years, Alternative 2A would have a negligible effect on water supply in the South Santiam River.

**Santiam**

Flows at Jefferson on the Santiam, downstream of the confluence of the North and South Santiam Rivers, are lower than the NAA from mid-March to mid-May in the driest years, but higher in the summer and fall in most years due to the fall drawdown operation at Green Peter Dam, as indicated in Appendix B, Figure B-164. As the flows are only lower during a portion of the spring and only in the driest years, Alternative 2A would have a negligible effect on water supply in the Santiam River.

**Long Tom River**

There would be no effect to M&I water supply or irrigation from the alternative, as there are no operational changes proposed at Fern Ridge Dam and the reservoir is not used to support mainstem flow targets.

**McKenzie River**

Operations affecting water supply in the McKenzie Basin include releasing water for the integrated temperature and habitat flow regime and augmenting these flows with water from the power pool, as necessary.

Flows at Vida on the McKenzie River would be lower than the NAA from April through mid-June but slightly higher in August and September in the driest years. As the flows would only be lower during a portion of the spring and only in the driest years, Alternative 2A would have a negligible effect on water supply in the McKenzie River.

**Middle Fork of the Willamette River**

Operations affecting water supply in the Middle Fork Willamette sub-basin include releasing water for the integrated temperature and habitat flow regime and augmenting these flows with water from the power pools at Lookout Point and Hills Creek, as necessary.

Flows at Jasper on the Middle Fork Willamette River, downstream of Hills Creek, Lookout Point, and Fall Creek reservoirs, are lower than the NAA from April through mid-June in most years, but higher than the NAA during the summer months. As the flows are only lower during a portion of the spring and only in drier years, Alternative 2A would have a negligible effect on water supply in the Middle Fork Willamette River.

**Coast Fork of the Willamette River and Row River**

Operations affecting water supply in the Coast Fork Willamette sub-basin include releasing water for the integrated temperature and habitat flow regime.

Flows at Goshen on the Coast Fork Willamette River, downstream of Dorena and Cottage Grove reservoirs, are only lower than the NAA from April through May in the driest years. As the flows are only lower during a portion of the spring and only in drier years, Alternative 2A would have a negligible effect on water supply in the Coast Fork Willamette River.

**Mainstem Willamette River**

Operations affecting water supply on the mainstem Willamette River include releasing water for the integrated temperature and habitat flow regime, augmenting these flows with water from the inactive and power pools, as necessary and available, and the fall drawdown at Green Peter for fish passage.

Flows at Harrisburg on the Willamette River, downstream of the McKenzie River confluence, are lower than the NAA from April through mid-June about 25% of the time, but higher or equal to the NAA during the summer months. As the flows are only lower during a portion of the spring, still staying above 5000 cfs, and only in the driest years, Alternative 2A would have a negligible effect on water supply in the Willamette River above Harrisburg.

Flows at Albany on the Willamette River, upstream of the Santiam River confluence, are lower than the NAA from April through mid-June in the drier years, but higher than in the NAA during the summer months. As the flows are only lower during a portion of the spring, still staying above 5500 cfs, and only in the driest years, Alternative 2A would have a negligible effect on water supply in the Willamette River above and immediately downstream of Albany.

Flows at Salem on the Willamette River, downstream of the Santiam River confluence, are lower than the NAA from April through mid-June about 25% of the time, but higher or equal to the NAA during the summer months. As the flows are only lower during a portion of the spring, still staying above 6000 cfs, and only in the driest years, Alternative 2A would have a negligible effect on water supply in the Willamette River near and downstream of Salem.

Overall, Alternative 2A would have a minor adverse effect on water supply in the North Santiam Basin and negligible effect on water supply on the rest of the tributaries and the mainstem Willamette River. This effect would be long term.

#### *3.13.3.3.3 Near-Term Operations Measure*

**North Santiam**

The near-term operations measure within the North Santiam Basin includes Fall/Winter downstream fish passage through the upper regulating outlets and spring fish passage through strategic use of spillway and turbines at Detroit Dam and spreading spill to reduce total dissolved gas at Big Cliff Dam.

The near-term operations measure would have no effect to water supply (M&I and agricultural irrigation) relative to the NAA as the operations directly affecting Detroit Dam do not reduce the ability of the reservoir to refill, and hence do not affect stored water potential. Due to implementation of the Integrated Flow Regime, Detroit reservoir would be expected to fill more often and higher in dry years, than in the NAA. Flows downstream of the dam would be similar under the near-term operations measure as they would be once Alternative 2A is fully implemented.

**South Santiam**

The near-term operations measure within the South Santiam Subbasin includes outplanting of adult Chinook above Green Peter Reservoir, downstream fish passage at Green Peter Dam via the spillway in the spring and fall, and downstream fish passage at Foster via the spillway in the spring and fall.

There is a potential for minor adverse effects to water supply in the South Santiam due to the near-term operations implemented at Green Peter and Foster dam and reservoirs, but only in the driest years. Green Peter reservoir does not fill as high under the near-term operations measure as it does in the NAA in the driest years. This would affect the ability to provide stored water for M&I and irrigation uses. Flows out of Foster reservoir would be lower in the driest years, due mainly to implementation of the Integrated Flow Regime.

**Mainstem Santiam**

Flows on the Santiam, downstream of the confluence of the North and South Santiam Rivers, are higher under the near-term operations measure than in the NAA, as indicated in Section 3.2.3.3.7. As the flows are higher under all years, there would be a minor beneficial effect to water supply on the mainstem Santiam River.

**Long Tom River**

There would be no effect to M&I water supply or irrigation from the near-term operations measure, as there are no operational changes proposed at Fern Ridge Dam.

**McKenzie River**

The near-term operations measure within the McKenzie Subbasin includes spring and fall drawdown for fish passage at Cougar Reservoir to a target elevation of 1505 feet.

While Blue River Reservoir fills more often, especially in dry years, under the near-term operations measure, Cougar Reservoir refill would be majorly impacted by the operation in the drier years. While the reservoir would refill in average years, the refill could occur later, likely impacting the ability for stored water users to adequately plan for a larger volume use. This would result in a moderate impact to M&I and irrigation stored water users.

As noted in Section 3.2.2.4.7, flow at Vida, the McKenzie River control point downstream of Blue River and Cougar dams, is similar when compared to the NAA. Water users holding live flow water rights would experience negligible impacts from the near-term operations measure.

**Middle Fork of the Willamette River**

The near-term operations measure includes actions at three projects in the Middle Fork sub-basin. Downstream fish passage is provided at Hills Creek by prioritizing the regulating outlets at night during the fall and winter. Hills Creek reservoir is also used in the spring to help fill Lookout Point reservoir for that project's spring spill operation for fish passage. Lookout Point would then be drawn down to near the regulating outlets during the fall to pass fish downstream. Fall Creek would be drawn down to the riverbed in the fall as it is under current conditions, but refill of the reservoir to full conservation pool would be delayed until late spring.

The near-term operations measure would impact the ability of Hills Creek reservoir to refill in the driest years and Lookout Point and Fall Creek reservoirs in all years. This lack of refill would have a major impact to M&I and irrigation users relying on stored water in the Middle Fork of the Willamette River.

As noted in Section 3.2.2.4.7, flows at Jasper would be lower in the summer and fall in all years. This would have moderate, adverse effects to water rights holders, specifically in the dry years.

**Coast Fork of the Willamette River and Row Rivers**

There are no near-term operations for the Coast Fork projects. The near-term operations measure would have negligible effects to water supply on the Coast Fork, as flows during the critical summer months would be similar as compared to the NAA.

**Mainstem Willamette at Salem**

Flows at Salem under implementation of the near-term operations measure would be fairly similar to the NAA; therefore, effects to live flow water rights holders would be negligible. Due to the combined effects of spring delayed refill operations at multiple dams, the near-term operations measure would have a minor, adverse effect to M&I water supply and irrigation users relying on stored water.

##### *3.13.3.3.4 Climate Change*

Water supply, both from water stored in Corps' reservoirs and from natural river flow, may be adversely affected in the future under a climate change induced hydrology. Climate change may result in less reliable refill of the reservoirs and drafting earlier to minimum conservation elevations to support downstream minimum flow targets, but less so compared to the NAA. Natural river flow in the summer would likely decrease due to climate change and would adversely affect water users as there may not be adequate water in the rivers to satisfy existing water rights.

#### ***3.13.3.4 Alternative 2B - Hybrid Alternative***

Alternative 2B combines structural and operational fish passage measures and includes integrated habitat and temperature minimum tributary flow targets, and reduced mainstem targets. These flow targets vary throughout the year and are dependent on the level of the reservoir relative to the rule curve. The difference between Alternative 2A and 2B is the fish passage measure at Cougar dam. Alternative 2A uses a structure that operates with existing reservoir fluctuations to pass fish downstream, whereas Alternative 2B includes an operation where the reservoir is drawdown to elevation 1330 feet to use the diversion tunnel to pass fish.

The combination of actions in Alternative 2B would result in a decrease of 64,000 acre-feet stored water compared to the NAA. The small decrease in system-wide conservation storage would have a minor adverse effect to municipal and industrial water supply and irrigation users of the conservation storage. Due to the expected limited level of demand for stored water on the McKenzie River, Alternative 2B would be expected to have only a minor adverse effect on storage allocations, mostly in the McKenzie sub-basin. Stored water would not be available to meet all M&I storage agreements and irrigation water service contracts in the driest years. The amount available would be determined on an annual basis based on realized storage volumes across the system.

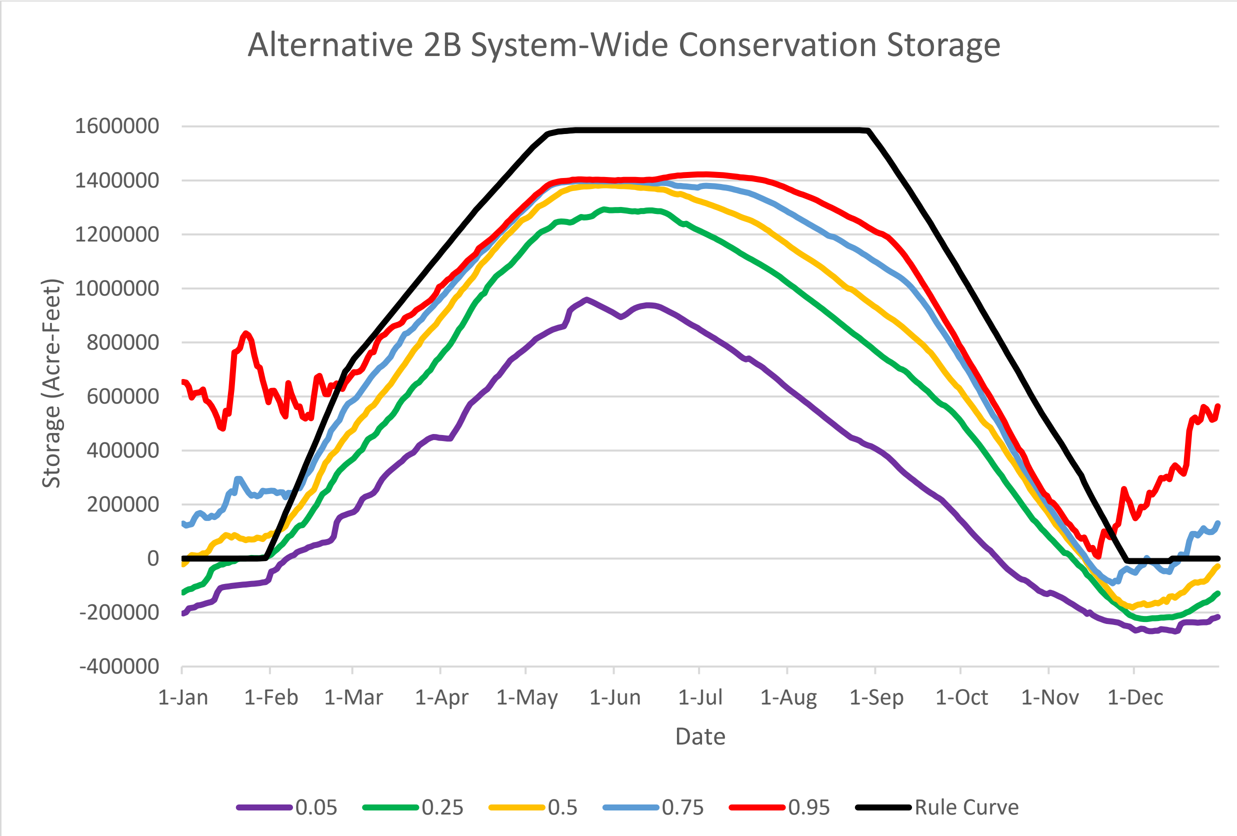


**Figure 3.13-5. System-Wide Conservation Storage Non-Exceedances Under Alternative 2B**

## North Santiam

Operations affecting water supply in the North Santiam Basin include releasing water for the integrated temperature and habitat flow regime and augmenting these flows with water from the power pool, as necessary.

Flow at Mehama, a key indicator for water supply users on the North Santiam, is slightly lower in the spring and late summer, dropping close to 1000 cfs during the late summer during the driest years, as compared to the NAA, reflecting the lower spring target flows from Detroit as compared to the NAA. Detroit Reservoir fills higher in these years and would reach minimum conservation pool later in the year, following the rule curve. Real time water management of the reservoir would be capable of managing flows in the North Santiam River, as to result in only a minor adverse effect to users relative to the NAA. This effect would be local and occur only in the driest years.

## South Santiam

Operations affecting water supply in the South Santiam Basin include releasing water for the integrated temperature and habitat flow regime, augmenting these flows with water from the power pool, as necessary, and a fall draw down operation for fish passage.

Flows at Waterloo on the South Santiam are lower than the NAA from mid-March to early-June in the driest years, but higher in the summer and fall in all years due to the fall drawdown operation at Green Peter Dam, as indicated in Appendix B, Figure B-165. As the flows are only lower during a portion of the spring and only in the driest years, Alternative 2B would have a negligible effect on water supply in the South Santiam River.

**Santiam**

Flows at Jefferson on the Santiam, downstream of the confluence of the North and South Santiam Rivers, are lower than the NAA from mid-March to mid-May in the driest years, but higher in the summer and fall in most years due to the fall drawdown operation at Green Peter Dam. As the flows are only lower during a portion of the spring and only in the driest years, Alternative 2B would have a negligible effect on water supply in the Santiam River.

**Long Tom River**

There would be no effect to M&I water supply or irrigation from the alternative, as there are no operational changes proposed at Fern Ridge Dam and the reservoir is not used to support mainstem flow targets.

**McKenzie River**

Operations affecting water supply in the McKenzie Basin include releasing water for the integrated temperature and habitat flow regime and drawing down the reservoir to the diversion tunnel in the spring and fall for fish passage.

The spring drawdown at Cougar affects the flow at Vida on the McKenzie River differently by season and by hydrologic conditions. Flows at Vida in the driest years are lower than the NAA from April through late summer. During wetter years, flows at Vida will be higher than the NAA until late May. As there would be no conservation storage to augment flows, summer flows would be lower than the NAA in the wettest years but nearly equal during most years. As the flows are only lower during a portion of the spring and only in the driest years, Alternative 2B would have a negligible effect on water supply in the McKenzie River.

**Middle Fork of the Willamette River**

Operations affecting water supply in the Middle Fork Willamette sub-basin include releasing water for the integrated temperature and habitat flow regime and augmenting these flows with water from the power pools at Lookout Point and Hills Creek, as necessary.

Flows at Jasper on the Middle Fork Willamette River, downstream of Hills Creek, Lookout Point, and Fall Creek reservoirs, are lower than the NAA from April through mid-June in most years, but higher than the NAA in the driest years, and nearly equal most years, during the summer months. As the flows are only lower during a portion of the spring and only in drier years, Alternative 2B would have a negligible effect on water supply in the Middle Fork Willamette River.

**Coast Fork of the Willamette River and Row River**

Operations affecting water supply in the Coast Fork Willamette sub-basin include releasing water for the integrated temperature and habitat flow regime.

Flows at Goshen on the Coast Fork Willamette River, downstream of Dorena and Cottage Grove reservoirs, are only lower than the NAA from April through May in the driest years. As the flows are only lower during a portion of the spring and only in drier years, Alternative 2B would have a negligible effect on water supply in the Coast Fork Willamette River.

**Mainstem Willamette River**

Operations affecting water supply on the mainstem Willamette River include releasing water for the integrated temperature and habitat flow regime, augmenting these flows with water from the inactive and power pools, as necessary and available, fall drawdown at Green Peter for fish passage, and spring and fall drawdowns at Cougar for fish passage.

Flows at Harrisburg on the Willamette River, downstream of the McKenzie River confluence, are lower than the NAA from April through mid-June during the driest years, but higher or equal to the NAA during the summer months. As the flows are only lower during a portion of the spring, still staying above 5000 cfs, and only in the driest years, Alternative 2B would have a negligible effect on water supply in the Willamette River above Harrisburg.

Flows at Albany on the Willamette River, upstream of the Santiam River confluence, are lower than the NAA from April through mid-June about 25% of the time, but higher than in the NAA during the summer months. As the flows are only lower during a portion of the spring, still staying above 4500 cfs, and only in the driest years, Alternative 2B would have a negligible effect on water supply in the Willamette River above and immediately downstream of Albany.

Flows at Salem on the Willamette River, downstream of the Santiam River confluence, are lower than the NAA from April through mid-June about 25% of the time, but higher or equal to the NAA during the summer months. As the flows are only lower during a portion of the spring, still staying above 6000 cfs, and only in the driest years, Alternative 2B would have a **negligible** effect on water supply in the Willamette River near and downstream of Salem.

Overall, Alternative 2B would have a minor adverse effect on water supply in the North Santiam Basin and negligible effect on water supply on the rest of the tributaries and the mainstem Willamette River. This effect would be long term.

##### *3.13.3.4.1 Near-Term Operations Measure*

See Alternative 2A, Section 3.13.3.3.3, for description of effects due to the Near-Term Operations Measure. The effects of the near-term operations would be the same under this alternative as the near-term operations do not change between alternatives.

#### *3.13.3.4.2 Climate Change*

Water supply, both from water stored in Corps' reservoirs and from natural river flow, may be adversely affected in the future under a climate change induced hydrology. As noted in Section 3.2.3.1.7, climate change may result in less reliable refill of the reservoirs and drafting earlier to minimum conservation elevations to support downstream minimum flow targets, similar to the NAA. Decreased summer baseflows would result in adverse effects to water users as there may not be adequate water in the rivers to satisfy existing water rights.

### ***3.13.3.5 Alternative 3A – Operations-Focused Fish Passage Alternative***

Alternative 3A is an operational fish passage alternative, combining spring spill and drawdowns with fall drawdowns at 6 of the 11 storage projects. These combined operations significantly affect system-wide conservation storage, resulting in system-wide storage being only 44% of the refill volume in the NAA, or 590,000 acre-feet, as shown below in Figure 3.13-6. System-Wide Conservation Storage Non-Exceedances Under Alternative 3A.

Due to conditions applied to the reallocation of storage from joint-use to specific uses in the WBR BiOp, it is likely that the water that would be stored would be needed to support minimum flows for fish and wildlife, leaving very little available for M&I water supply or irrigation. Therefore, Alternative 3A would have a major adverse effect to the storage allocations and M&I water supply and irrigation users of conservation storage.

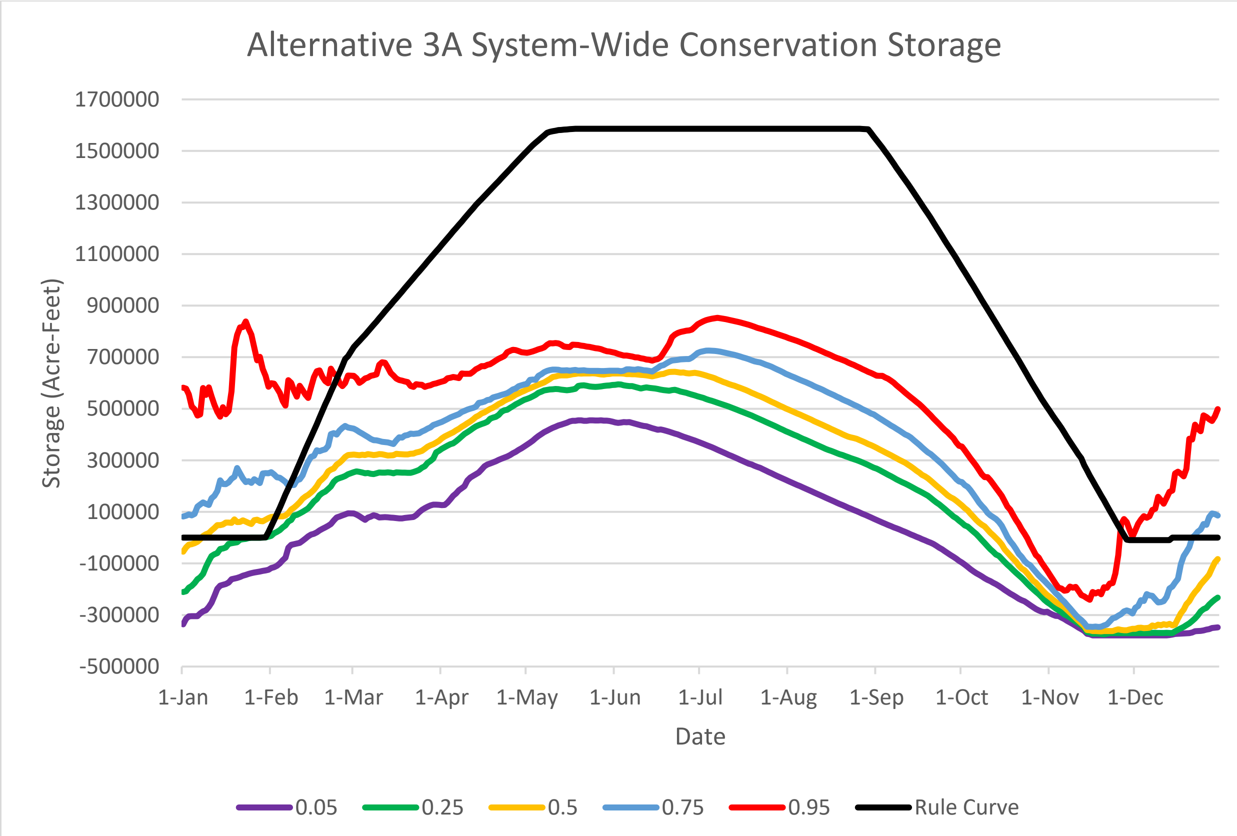


**Figure 3.13-6. System-Wide Conservation Storage Non-Exceedances Under Alternative 3A**

**North Santiam**

Operations affecting water supply in the North Santiam Basin include releasing water for the integrated temperature and habitat flow regime, augmenting these flows with water from the power pool, as necessary, and drawing down the reservoir in the spring and fall for fish passage.

Under Alternative 3A, Detroit reservoir would be held below minimum conservation pool and as noted in Section 3.2.2.6.1, would very rarely fill into the conservation pool, nearly eliminating the ability to augment naturally low flows. Due to the spring drawdown and need to pass inflows instead of storing water, flows at Mehama in the spring, from March through early to late May, depending on the type of water year, are higher under Alternative 3A as compared to the NAA. Starting in June, flows drop lower than in the NAA as there is little to no water in the conservation pool to augment naturally low flows. Flows at Mehama could drop to less than 750 cfs for extended periods about 50% of the time. This could cause curtailment of water rights for M&I water supply and irrigation and would cause issues at the City of Salem's drinking water intake facility, which requires a minimum flow of 750 cfs for the intake structure to operate. Therefore, Alternative 3A would have a major adverse effect to M&I water supply and irrigation. This effect would be long term in that it would occur in most years and during the critically low flow season.

**South Santiam**

Operations affecting water supply in the South Santiam Basin include releasing water for the integrated temperature and habitat flow regime, augmenting these flows with water from the power pool, as necessary, and a fall draw down operation for fish passage.

Flows at Waterloo on the South Santiam are lower than the NAA from mid-March to early-June in the driest years due to reduced flow targets, but higher in the summer and fall in all years due to the fall drawdown operation at Green Peter Dam. As the flows are only lower during a portion of the spring and only in the driest years, Alternative 3A would have a negligible effect on water supply in the South Santiam River.

**Santiam**

Flows at Jefferson on the Santiam, downstream of the confluence of the North and South Santiam Rivers, in Alternative 3A are affected by the combination of a spring drawdown operation at Detroit and fall drawdown operations at both Detroit and Green Peter. Flows are slightly higher than the NAA from mid-March to mid-June except in the driest years. Flows in the summer are nearly equal to the NAA. Flows in the fall are lower than the NAA about half the time. As the flows are nearly equal during the critical low flow summer season, Alternative 3A would have a negligible effect on water supply in the Santiam River.

**Long Tom River**

There would be no effect to M&I water supply or irrigation from the alternative, as there are no operational changes proposed at Fern Ridge Dam and the reservoir is not used to support mainstem flow targets.

**McKenzie River**

Operations affecting water supply in the McKenzie Basin include releasing water for the integrated temperature and habitat flow regime, augmenting these flows with water from the power pool, as necessary, and drawing down the reservoir to the regulating outlets in the spring and fall for fish passage.

Flows at Vida are higher in the spring than in the NAA for all but the driest years, as the reservoir needs to pass inflows to keep the pool drawn down for the fish passage operation in both the spring and fall. Flows in the summer are nearly equal to the NAA, but lower in the fall. This is due to not needing to empty the reservoir in preparation for the winter flood management season. As flows are nearly equal, especially for drier years, during the low flow season Alternative 3A would have a negligible effect on water supply in the McKenzie River.

**Middle Fork of the Willamette River**

Operations affecting water supply in the Middle Fork Willamette sub-basin include releasing water for the integrated temperature and habitat flow regime, augmenting these flows with water from the power pools at Lookout Point and Hills Creek, as necessary and available, and drawing down Lookout Point reservoir in the spring and fall and drawing down Hills Creek reservoir in the fall for fish passage.

Flows at Jasper are higher than in the NAA through mid-May for all years, and through mid-June for wetter years, due to the spring drawdown operation at Lookout Point which prevents storing of water into the conservation pool until mid-June. When the reservoir does start storing water, flows in the Middle Fork Willamette drop drastically most years, closer to what would be realized during dry years in both Alternative 3A and the NAA. Flows during the driest years are nearly equal to the NAA conditions during spring and most of summer, until September when there isn't water in the conservation pools to supplement naturally very low flows. As the flows are lower during the summer, approaching existing dry year conditions, Alternative 3A would have a moderate adverse effect on water supply in the Middle Fork Willamette River.

**Coast Fork of the Willamette River and Row River**

Operations affecting water supply in the Coast Fork Willamette sub-basin include releasing water for the integrated temperature and habitat flow regime and augmenting these flows with water from the inactive pools at Dorena and Cottage Grove reservoirs, as necessary and available.

Flows at Goshen on the Coast Fork Willamette River, downstream of Dorena and Cottage Grove reservoirs, are only lower than the NAA from April through May in the driest years. As the flows are only lower during a portion of the spring and only in drier years, Alternative 3A would have a negligible effect on water supply in the Coast Fork Willamette River.

**Mainstem Willamette River**

Operations affecting water supply on the mainstem Willamette River include releasing water for the integrated temperature and habitat flow regime, augmenting these flows with water from the inactive and power pools, as necessary and available, drawing down Detroit, Cougar, and Lookout Point reservoirs in the spring and fall for fish passage, and drawing down Green Peter and Hills Creek reservoir in the fall for fish passage.

Flows at Harrisburg on the Willamette River, downstream of the McKenzie River confluence, are lower than the NAA from April through mid-June during the driest years, but higher or equal to the NAA during the summer months. As the flows are only lower during a portion of the spring, still staying above 5000 cfs, and only in the driest years, Alternative 3A would have a negligible effect on water supply in the Willamette River above Harrisburg.

Flows at Albany on the Willamette River, upstream of the Santiam River confluence, are lower than the NAA from April through mid-June during the driest years and nearly equal to the NAA flows during the summer months. As the flows are only lower during a portion of the spring, staying above 3000 cfs, and only in the driest years, Alternative 3A would have a negligible effect on water supply in the Willamette River above and immediately downstream of Albany.

Flows at Salem on the Willamette River, downstream of the Santiam River confluence, are lower than the NAA from April through mid-June during the driest years and lower during the summer for most years. As the flows would still stay above 6000 cfs most of the time, Alternative 3A would have a negligible effect on water supply in the Willamette River near and downstream of Salem.

Alternative 3A would have a major adverse effect on storage allocations. Alternative 3A would have a major adverse effect on water supply in the North Santiam Basin, moderate adverse effect on the Middle Fork Willamette, and negligible effect on water supply on the rest of the tributaries and the mainstem Willamette River. This effect would be long term.

##### *3.13.3.5.1 Near-Term Operations Measure*

See Alternative 2A for description of effects due to the Near-Term Operations Measure. The effects of the near-term operations would be the same under this alternative as the near-term operations do not change between alternatives.

##### *3.13.3.5.2 Climate Change*

Water supply, both from water stored in Corps' reservoirs and from natural river flow, may be adversely affected in the future under a climate change induced hydrology. Climate change would exacerbate the major adverse effects to storage realized due to fish passage operations. Natural river flow in the summer would likely decrease due to climate change and would also adversely affect water users as there may not be adequate water in the rivers to satisfy existing water rights.

#### ***3.13.3.6 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at COU)***

Alternative 3B is also an operational fish passage alternative, combining spring spill and drawdowns with fall drawdowns at 6 of the 11 storage projects. These combined operations significantly affect system-wide conservation storage, resulting in system-wide storage being only 50% of the refill volume in the NAA, or 669,000 acre-feet, as indicated in Figure 3.13-7. System-Wide Conservation Storage Non-Exceedances Under Alternative 3B. Due to conditions applied to the reallocation of storage from joint-use to specific uses in the WBR BiOp, it is likely that the water that is stored would be needed to meet minimum flows for fish and wildlife, leaving very little available for water supply or irrigation. This would result in a major adverse effect to the storage allocations and users relying on the stored water for M&I water supply and irrigation.

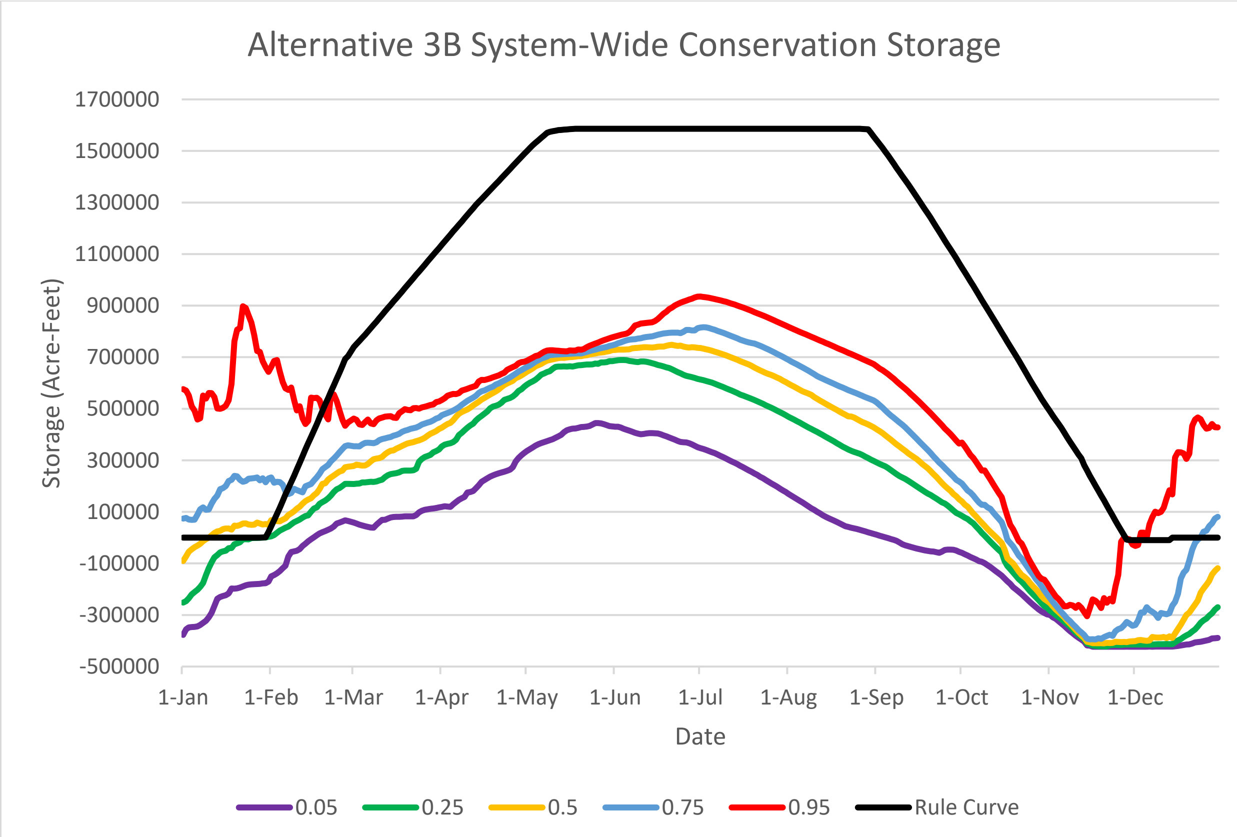


**Figure 3.13-7. System-Wide Conservation Storage Non-Exceedances Under Alternative 3B**

**North Santiam**

Operations affecting water supply in the North Santiam Basin include releasing water for the integrated temperature and habitat flow regime, augmenting these flows with water from the power pool, as necessary, and drawing down the reservoir in the fall for fish passage.

Flow at Mehama, a key indicator for water supply users on the North Santiam, is slightly lower in the spring and late summer, dropping close to 1000 cfs during the late summer during the driest years, as compared to the NAA, reflecting the lower spring target flows from Detroit as compared to the NAA. Flows in September would be higher in all but the driest years as the reservoir is drafted for the fall drawdown operation for fish passage. Real time water management of the reservoir would be capable of managing flows in the North Santiam River in the driest years to minimize adverse effects; therefore, Alternative 3B would only have a minor adverse effect to users relative to the NAA. This effect would be local and occur only in the driest years.

**South Santiam**

Operations affecting water supply in the South Santiam Basin include releasing water for the integrated temperature and habitat flow regime, augmenting these flows with water from the power pool, as necessary, and drawing down the reservoir in the spring and fall for fish passage.

Under Alternative 3B, Green Peter reservoir would be held below minimum conservation pool, rarely filling into the conservation pool, nearly eliminating the ability to augment naturally low flows in the summer. Due to the spring drawdown and need to pass inflows instead of storing water, flows at Waterloo in the spring, from March through early to late May, depending on the type of water year, are higher under Alternative 3B as compared to the NAA. Starting in June (May for driest years), flows drop lower than in the NAA as there is little to no water in the conservation pool to augment naturally low flows. Flows at Waterloo could drop to near 100 cfs for extended periods about 25% of the time. This could cause curtailment of water rights. Therefore, Alternative 3B would have a major adverse effect to M&I water supply and irrigation on the South Santiam River. This effect would be long term in that it would occur in most years and during the critically low flow season.

**Santiam**

Flows at Jefferson on the Santiam, downstream of the confluence of the North and South Santiam Rivers, in Alternative 3B are affected by the combination of a spring drawdown operation at Green Peter and fall drawdown operations at both Detroit and Green Peter. Flows are very similar to those expected under Alternative 3A: slightly higher than the NAA from mid-March to mid-June except in the driest years when flows would be lower than the NAA starting in late April. Flows in the summer are nearly equal to the NAA. Flows in the fall are lower than the NAA about half the time. As the flows are slightly lower than during the critical low flow summer season, Alternative 3B would have a minor adverse effect on water supply in the Santiam River.

**Long Tom River**

There would be no effect to M&I water supply or irrigation from the alternative, as there are no operational changes proposed at Fern Ridge Dam and the reservoir is not used to support mainstem flow targets.

**McKenzie River**

Operations affecting water supply in the McKenzie Basin include releasing water for the integrated temperature and habitat flow regime and drawing down the reservoir to the diversion tunnel in the spring and fall for fish passage.

Even though Alternative 3B has a more deeper spring drawdown operation at Cougar reservoir, flows at Vida are very similar to those expected to occur under Alternative 3A, i.e., higher in the spring than in the NAA for all but the driest years, as the reservoir needs to pass inflows to keep the pool drawn down for the fish passage operation in both the spring and fall. Flows in the summer are nearly equal to the NAA, but lower in the fall. This is due to not needing to empty the reservoir in preparation for the winter flood management season. As flows are nearly equal, especially for drier years, during the low flow season Alternative 3B would have a negligible effect on water supply in the McKenzie River.

**Middle Fork of the Willamette River**

Operations affecting water supply in the Middle Fork Willamette sub-basin include releasing water for the integrated temperature and habitat flow regime, augmenting these flows with water from the power pools at Lookout Point and Hills Creek, as necessary and available, and drawing down Lookout Point reservoir in fall and drawing down Hills Creek reservoir in the spring and fall for fish passage.

Flows at Jasper would be higher than in the NAA spring through fall in about 50% of years. For drier years, flows would be slightly less than the NAA April through mid-June, but then slightly higher until late August. During the driest years, flow would again be lower than then NAA, going down close to 1000 cfs at times. As the flows are lower during late summer and early fall, Alternative 3B would have a minor adverse effect on water supply in the Middle Fork Willamette River.

**Coast Fork of the Willamette River and Row River**

Operations affecting water supply in the Coast Fork Willamette sub-basin include releasing water for the integrated temperature and habitat flow regime and augmenting these flows with water from the inactive pools at Dorena and Cottage Grove reservoirs, as necessary and available.

Flows at Goshen on the Coast Fork Willamette River, downstream of Dorena and Cottage Grove reservoirs, are only lower than the NAA from April through May in the driest years. As the flows are only lower during a portion of the spring and only in drier years, Alternative 3B would have a negligible effect on water supply in the Coast Fork Willamette River.

**Mainstem Willamette River**

Operations affecting water supply on the mainstem Willamette River include releasing water for the integrated temperature and habitat flow regime, augmenting these flows with water from the inactive and power pools at Lookout Point and Hills Creek, as necessary and available, drawing down Detroit and Lookout Point reservoirs in the fall for fish passage, and drawing down Green Peter, Cougar, and Hills Creek reservoirs in the spring and fall for fish passage.

Flows at Harrisburg on the Willamette River, downstream of the McKenzie River confluence, are lower than the NAA from April through mid-June during the driest years, but higher or equal to the NAA during the summer months for all years. As flows are only lower during a portion of the spring, still staying above 5000 cfs during that time-period, and only in the driest years, Alternative 3B would have a negligible effect on water supply in the Willamette River above and immediately downstream of Harrisburg.

Flows at Albany on the Willamette River, upstream of the Santiam River confluence, are lower than the NAA from April through mid-June during drier years. Flows in the summer would be equal to or higher than in the NAA during the summer months, with flows dipping below NAA levels sporadically in late September and early October. As the flows are only lower during a portion of the spring, staying above 6000 cfs during this period, and only in the driest years, Alternative 3B would have a negligible effect on water supply in the Willamette River above and immediately downstream of Albany.

Flows at Salem on the Willamette River, downstream of the Santiam River confluence, are lower than the NAA from April through mid-June and September during the driest years. As the flows would still stay above 6000 cfs most of the time, Alternative 3B would have a negligible effect on water supply in the Willamette River near and downstream of Salem.

Alternative 3b would have a major adverse effect on storage allocations. Alternative 3B would have a major adverse effect on water supply in the South Santiam Basin, minor adverse effect on the North Santiam, Santiam, and Middle Fork Willamette sub-basins, and negligible effect on water supply on McKenzie and Coast Fork Willamette and mainstem Willamette River. This effect would be long term.

##### *3.13.3.6.1 Near-Term Operations Measure*

See Alternative 2A, Section 3.13.3.3.3, for description of effects due to the Near-Term Operations Measure. The effects of the near-term operations would be the same under this alternative as the near-term operations do not change between alternatives.

##### *3.13.3.6.2 Climate Change*

Water supply, both from water stored in Corps' reservoirs and from natural river flow, may be adversely affected in the future under a climate change induced hydrology. Climate change would exacerbate the major adverse effects to storage realized due to fish passage operations. Natural river flow in the summer would likely decrease due to climate change and would also adversely affect water users as there may not be adequate water in the rivers to satisfy existing water rights.

#### ***3.13.3.7 Alternative 4 – Structures-Based Fish Passage Alternative***

Alternative 4 is a structural fish passage alternative that includes an integrated habitat and temperature minimum flow regime. As the structures are designed to work with existing levels of reservoir fluctuations, the reservoirs are more likely to refill than they are in Alternative 2B, and especially Alternatives 3A and 3B, due to reservoir drawdowns in the spring for fish passage. As with the reduced minimum flows in Alternative 1, the integrated habitat and temperature flow regime with lower spring mainstem targets results in increased system-wide conservation storage. Figure 3.13-8. System-Wide Conservation Storage Non-Exceedances Under Alternative 4shows system-wide conservation storage would be 1,451,000 acre-feet, an increase of 122,000 acre-feet at the 75% exceedance level compared to the NAA, resulting in more reliable use of stored water, including for municipal and industrial water supply and irrigation than realized in the NAA. Stored water would still not be available to meet all M&I storage agreements and irrigation water service contracts in the driest years, but to a lesser extent than in the NAA. The amount available would be determined on an annual basis based on realized storage volumes across the system. Alternative 4 would have a minor beneficial effect to system-wide storage allocations. This effect would be realized long term and basin-wide.

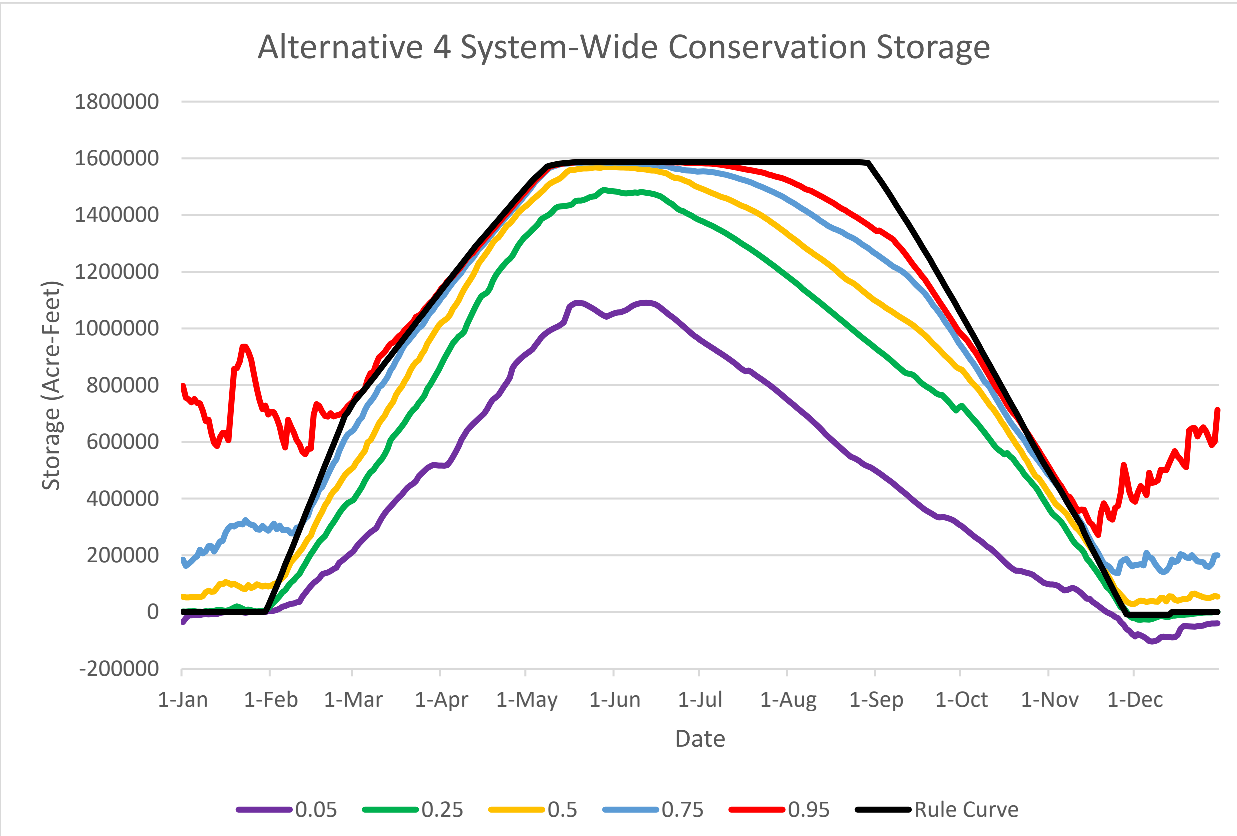


**Figure 3.13-8. System-Wide Conservation Storage Non-Exceedances Under Alternative 4**

**<u>North Santiam</u>**

Operations affecting water supply in the North Santiam Basin include releasing water for the integrated temperature and habitat flow regime and augmenting these flows with water from the power pool, as necessary.

Flow at Mehama, a key indicator for water supply users on the North Santiam, is slightly lower in the spring and late summer, dropping close to 1000 cfs during the late summer during the driest years, as compared to the NAA, reflecting the lower, dry year target flows from Detroit as compared to the NAA. Detroit Reservoir fills higher in these years and would reach minimum conservation pool later in the year, following the rule curve. Real time water management of the reservoir would be capable of managing flows in the North Santiam River, as to result in only a minor adverse effect to users relative to the NAA. This effect would be local and occur only in the driest years.

**South Santiam**

Operations affecting water supply in the South Santiam Basin include releasing water for the integrated temperature and habitat flow regime and augmenting these flows with water from the power pool, as necessary.

Flows at Waterloo on the South Santiam are lower than the NAA from mid-March to early-June in the driest years, but higher through the summer during most years. As the flows are only lower during a portion of the spring and only in the driest years, Alternative 4 would have a negligible effect on water supply in the South Santiam River.

**Santiam**

Flows at Jefferson on the Santiam, downstream of the confluence of the North and South Santiam Rivers, are lower than the NAA from mid-March to mid-May in the driest years, but higher, or nearly equal, in the summer and fall in most years. As the flows are only lower during a portion of the spring and only in the driest years, Alternative 4 would have a negligible effect on water supply in the Santiam River.

**Long Tom River**

There would be no effect to M&I water supply or irrigation from the alternative, as there are no operational changes proposed at Fern Ridge Dam and the reservoir is not used to support mainstem flow targets.

**McKenzie River**

Operations affecting water supply in the McKenzie Basin include releasing water for the integrated temperature and habitat flow regime and augmenting these flows with water from the power pool, as necessary.

Flows at Vida on the McKenzie River are lower than the NAA from April through mid-June but slightly higher in August and September in the driest years. As the flows are only lower during a portion of the spring and only in the driest years, Alternative 4 would have a negligible effect on water supply in the McKenzie River.

**Middle Fork of the Willamette River**

Operations affecting water supply in the Middle Fork Willamette sub-basin include releasing water for the integrated temperature and habitat flow regime and augmenting these flows with water from the power pools at Lookout Point and Hills Creek, as necessary.

Flows at Jasper on the Middle Fork Willamette River, downstream of Hills Creek, Lookout Point, and Fall Creek reservoirs, are lower than the NAA from April through mid-June in most years, but higher than the NAA during the summer months. As the flows are only lower during a portion of the spring and only in drier years, Alternative 4 would have a negligible effect on water supply in the Middle Fork Willamette River.

**Coast Fork of the Willamette River and Row River**

Operations affecting water supply in the Coast Fork Willamette sub-basin include releasing water for the integrated temperature and habitat flow regime and augmenting these flows with water from the inactive pools at Dorena and Cottage Grove reservoirs, as necessary and available.

Flows at Goshen on the Coast Fork Willamette River, downstream of Dorena and Cottage Grove reservoirs, are only lower than the NAA from April through May in the driest years. As the flows are only lower during a portion of the spring and only in drier years, Alternative 4 would have a negligible effect on water supply in the Coast Fork Willamette River.

**Mainstem Willamette River**

Operations affecting water supply on the mainstem Willamette River include releasing water for the integrated temperature and habitat flow regime and augmenting these flows with water from the inactive and power pools, as necessary and available.

Flows at Harrisburg on the Willamette River, downstream of the McKenzie River confluence, are lower than the NAA from April through mid-June about 25% of the time, but higher or equal to the NAA during the summer months. As the flows are only lower during a portion of the spring, still staying above 4000 cfs, and only in the driest years, Alternative 4 would have a negligible effect on water supply in the Willamette River above Harrisburg.

Flows at Albany on the Willamette River, upstream of the Santiam River confluence, are lower than the NAA from April through mid-June about 25% of the time, but higher than in the NAA during the summer months. As the flows are only lower during a portion of the spring, still staying above 4500 cfs, and only in the driest years, Alternative 4 would have a negligible effect on water supply in the Willamette River above and immediately downstream of Albany.

Flows at Salem on the Willamette River, downstream of the Santiam River confluence, are lower than the NAA from April through mid-June about 25% of the time, but higher or equal to the NAA during the summer months. As the flows are only lower during a portion of the spring, still staying above 6000 cfs, and only in the driest years, Alternative 4 would have a negligible effect on water supply in the Willamette River near and downstream of Salem.

Alternative 4 would have a moderate beneficial effect on storage allocations and minor adverse effect on water supply in the North Santiam Basin and negligible effect on water supply on the rest of the tributaries and the mainstem Willamette River. This effect would be long term.

##### *3.13.3.7.1 Near-Term Operations Measure*

See Alternative 2A for description of effects due to the Near-Term Operations Measure. The effects of the near-term operations would be the same under this alternative as the near-term operations do not change between alternatives.

##### *3.13.3.7.2 Climate Change*

Water supply, both from water stored in Corps' reservoirs and from natural river flow, may be adversely affected in the future under a climate change induced hydrology. Change may result in less reliable refill of the reservoirs and drafting earlier to minimum conservation elevations to support downstream minimum flow targets, similar to Alternative 1. Natural river flow in the summer would likely decrease due to climate change and would also adversely affect water users as there may not be adequate water in the rivers to satisfy existing water rights.

#### *3.13.3.8 Alternative 5 – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 5 has the same measures as Alternative 2B but uses the Revised Integrated Habitat and Temperature Flow Regime (M30b) that includes higher mainstem flow targets than M30. The combination of actions in Alternative 5 would result in a decrease of 98,536 acre-feet of stored water compared to the NAA. Stored water would not be available to meet all M&I storage agreements and irrigation water service contracts in the driest years. The amount available would be determined on an annual basis based on realized storage volumes across the system. The small decrease in system-wide conservation storage would have a minor adverse effect to municipal and industrial water supply and irrigation users of the conservation storage. Due to the expected limited level of demand for stored water on the McKenzie River, Alternative 5 would be expected to have only a minor adverse effect to system-wide storage allocations.

**North Santiam**

Operations affecting water supply in the North Santiam Basin include releasing water for the modified integrated temperature and habitat flow regime and augmenting these flows with water from the power pool, as necessary.

Flow at Mehama, a key indicator for water supply users on the North Santiam, is slightly lower in the spring and late summer, dropping close to 1000 cfs during the late summer during the drier years, as compared to the NAA, reflecting the lower spring target flows from Detroit as compared to the NAA for dry years. Detroit Reservoir fills higher in these years and would reach minimum conservation pool later in the year, following the rule curve. Real time water management of the reservoir would be capable of managing flows in the North Santiam River, as to result in only a minor adverse effect to users relative to the NAA. This effect would be local and occur only in the driest years.

**South Santiam**

Operations affecting water supply in the South Santiam Basin include releasing water for the modified integrated temperature and habitat flow regime and augmenting these flows with water from the power pool, as necessary.

Flows at Waterloo on the South Santiam are lower than the NAA from mid-March to early-June in the driest years due to reduced tributary flow target, higher in the summer most years due to a higher flow target than in the NAA, and much higher in September and the first half of October in all years due to the fall drawdown operation at Green Peter Dam. As the flows are only lower during a portion of the spring and only in the driest years, Alternative 5 would have a negligible effect on water supply in the South Santiam River.

**Santiam**

Flows at Jefferson on the Santiam, downstream of the confluence of the North and South Santiam Rivers, are lower than the NAA from mid-March to mid-May in the driest years, but higher in the summer due to higher summer flow targets, and higher in fall in most years due to the fall drawdown operation at Green Peter Dam. As the flows are only lower during a portion of the spring and only in the driest years, Alternative 5 would have a negligible effect on water supply in the Santiam River.

**Long Tom River**

There would be no effect to M&I water supply or irrigation from the alternative, as there are no operational changes proposed at Fern Ridge Dam and the reservoir is not used to support mainstem flow targets.

**McKenzie River**

Operations affecting water supply in the McKenzie Basin include releasing water for the modified integrated temperature and habitat flow regime and drawing down the reservoir to the diversion tunnel in the spring and fall for fish passage.

The spring drawdown at Cougar affects the flow at Vida on the McKenzie River differently by season and by hydrologic conditions. Flows at Vida in the driest years are lower than the NAA from April all year except for about the first two weeks of March when the Cougar reservoir is drafted for the spring drawdown operation for fish passage. During wetter years, flows at Vida will be higher than the NAA until early June when Cougar reservoir is nearly empty and there is not stored water available to augment streamflow on the McKenzie nor in the mainstem Willamette River. As there would be no conservation storage to augment flows, summer flows would be lower than the NAA in the wettest years but same as the NAA during most years. As the flows are only lower during a portion of the spring and only in the driest years, Alternative 5 would have a negligible effect on water supply in the McKenzie River.

**Middle Fork of the Willamette River**

Operations affecting water supply in the Middle Fork Willamette sub-basin include releasing water for the modified integrated temperature and habitat flow regime and augmenting these flows with water from the power pools at Lookout Point and Hills Creek, as necessary.

Flows at Jasper on the Middle Fork Willamette River, downstream of Hills Creek, Lookout Point, and Fall Creek reservoirs, are lower than the NAA from April through mid-June in most years, but higher than the NAA in the driest years, and nearly equal most years, during the summer months. As the flows are only lower during a portion of the spring and only in drier years and higher in the summer, Alternative 5 would have a negligible effect on water supply in the Middle Fork Willamette River.

**Coast Fork of the Willamette River and Row River**

Operations affecting water supply in the Coast Fork Willamette sub-basin include releasing water for the modified integrated temperature and habitat flow regime.

Flows at Goshen on the Coast Fork Willamette River, downstream of Dorena and Cottage Grove reservoirs, are only lower than the NAA from April through May in the driest years. As the flows are only lower during a portion of the spring and only in driest years, Alternative 5 would have a negligible effect on water supply in the Coast Fork Willamette River.

**Mainstem Willamette River**

Operations affecting water supply on the mainstem Willamette River include releasing water for the modified integrated temperature and habitat flow regime and augmenting these flows with water from the inactive and power pools, as necessary and available.

Flows at Harrisburg on the Willamette River, downstream of the McKenzie River confluence, are lower than the NAA from April through mid-June during drier years, but higher or equal to the NAA during the summer months, except for the wettest years when the flows in the late summer are slightly less than in the NAA. As the low flows are only lower during a portion of the spring, still staying above 5000 cfs, and only in the driest years, Alternative 5 would have a negligible effect on water supply in the Willamette River above and around Harrisburg.

Flows at Albany on the Willamette River, upstream of the Santiam River confluence, are lower than the NAA from April through mid-June about 25% of the time, but higher than in the NAA during the summer months. As the flows are only lower during a portion of the spring, still staying above 5000 cfs, and only in the driest years, Alternative 5 would have a negligible effect on water supply in the Willamette River above and immediately downstream of Albany.

Flows at Salem on the Willamette River, downstream of the Santiam River confluence, are lower than the NAA from April through mid-June about 25% of the time, but higher or equal to the NAA during the summer months. As the flows are only lower during a portion of the spring, still staying above 6000 cfs, and only in the driest years, Alternative 5 would have a negligible effect on water supply in the Willamette River near and downstream of Salem.

Alternative 5 would have a moderate beneficial effect on storage allocations and minor adverse effect on water supply in the North Santiam Basin and negligible effect on water supply on the rest of the tributaries and the mainstem Willamette River. This effect would be long term.

###### *3.13.3.8.1 Near-Term Operations Measure*

See Alternative 2A for description of effects due to the Near-Term Operations Measure. The effects of the near-term operations would be the same under this alternative as the near-term operations do not change between alternatives.

###### *3.13.3.8.2 Climate Change*

Water supply, both from water stored in Corps' reservoirs and from natural river flow, may be adversely affected in the future under a climate change induced hydrology. Climate change may result in less reliable refill of the reservoirs and drafting earlier to minimum conservation elevations to support downstream minimum flow targets, similar to Alternative 2B. Natural river flow in the summer would likely decrease due to climate change and would also adversely affect water users as there may not be adequate water in the rivers to satisfy existing water rights.

## 3.14 RECREATION

The analysis of recreational resources identifies recreational facilities, visitation trends, revenue, and the overall recreational experience that may be affected by the Proposed Action and alternatives. The analysis considers how the Proposed Action might affect the recreational resources and its recreational value to individuals and communities within the Willamette River Basin (WRB). Potential impacts would be felt most by residents, communities, and businesses near each of the USACE projects. However, recreationists, businesses, and recreational outfitters throughout the WRB would also be impacted by the proposed alternatives, and therefore, the boundary of the WRB is defined as the area of analysis. This includes the 13 Oregon counties that intersect or lie within the boundary: Benton, Clackamas, Columbia, Douglas, Klamath, Lane, Linn, Marion, Multnomah, Polk, Tillamook, Washington, and Yamhill counties.

Some information in this section (such as the descriptions of state park amenities) comes from the Oregon Parks and Recreation Department’s 2019-2023 Statewide Comprehensive Outdoor Recreation Plan (SCORP). The Oregon SCORP identifies state-wide trends in recreational needs and participation. In addition to information provided by the SCORP and Lake Level Reports, the amenities and activities available at recreation sites managed by Lane County, Linn County, the U.S. Forest Service (USFS), Oregon Parks and Recreation Department (OPRD), Oregon Department of Fish and Wildlife (ODFW), Bureau of Land Management (BLM), and private entities are sourced from the best available online resources maintained by the managing agency. Information on fishing at each of the reservoirs is based on ODFW’s Recreation Report for the “Willamette Zone” (i.e., WRB).

USACE publishes *Value to the Nation Fast Facts Reports* that provide a “Lake Level Report” for each of the reservoirs and include statistics such as type of recreational facilities available and visitation and economic effects of the available activities. However, at some reservoirs, there are non-USACE facilities that have their own associated visitation and economic data (primarily campgrounds) which are not captured in the *Value to the Nation Fast Facts Reports*. As such, USACE used GIS analysis and local, county, and state data to capture visitation and economic effects at these non-USACE campgrounds. The methodology is described in more detail in Section 1.1 of Appendix K - Recreation Technical Report.

### 3.14.1 Willamette Valley System

Within the Willamette Valley System (WVS), USACE cooperates with the USFS, OPRD, ODFW, BLM, Lane and Linn County parks, and private organizations to build and manage more than 50 recreation sites around USACE reservoirs. Recreation is a congressionally authorized project purpose at all of USACE WVS reservoirs. The conservation pool is largely used to fulfill the USACE recreation mission as a number of the reservoirs are heavily used for recreational purposes during the conservation season, which in the WVS is from March to October. Visitation slowly increases from April to May followed by peak visitation between Memorial Day and Labor Day and then a decline after September. The three most important reservoirs for recreational us are Detroit, Fern Ridge, and Foster; these three reservoirs are last to be drained to meet summer instream flow objectives (USACE 2019a).

Recreation within the vicinity of each USACE reservoir is both water- and land-based. Water-based recreation includes activities that are dependent on access to a body of water such as fishing, boating, or swimming and to facilities such as boat ramps, marinas, and docks. In 2017, 40 percent of Oregon's population participated in recreation around lakes, reservoirs, and rivers (OPRD 2019). Land-based recreation includes camping, hiking, or wildlife viewing and relies on access to facilities such as campgrounds, trails, and picnic areas. There were approximately 2,882,010 total annual visitors to USACE reservoirs in the WVS during 2021, resulting in a total annual recreation value of 21,689,601. The following sections describe the estimated total annual visitors and recreational value of each of the USACE reservoirs in the WVS[47]. See Appendix K – Recreation Technical Report for more information.

The area of analysis overlaps with the Willamette National Forest (WNF), Umpqua National Forest, and Mt. Hood National Forest; however, none of the USACE reservoirs are located within the Umpqua National Forest or Mt. Hood National Forest. The recreation sites that are located within the WNF are operated by USFS. The WNF spans 110 miles along the western slopes of the Cascade Mountain Range and offers visitors views of high mountains, narrow canyons, cascading streams, and wooded slopes (USFS 2021). All or portions of Detroit, Big Cliff, Cougar, Blue River, Lookout Point, and Hills Creek reservoirs are located within the WNF. During the 2020 wildfire season, three wildfires (Beachie Creek, Lionshead and Holiday Farm) damaged many recreation sites, forest structures, and road corridors in parts of the WNF (USFS 2020). As of August 2021, USFS is tracking the extent of the Middle Fork Complex Wildfire near Fall Creek and Hills Creek reservoirs as well as the Bruler Fire approximately 8 miles south of Detroit Reservoir (USFS 2021). Closures of any recreation sites due to fires are noted throughout the section.

#### *3.14.1.1 Detroit*

Detroit Dam and Reservoir is located in the rugged mountain forests below Mt. Jefferson at river mile 49 on the North Santiam River, about 45 miles southeast of Salem, Oregon. River miles refer to the distance along a river upstream from the mouth of the river (i.e., where the river empties into another body of water). Recreation sites around Detroit Reservoir are accessible via North Santiam Highway (Oregon Route 22) and local roads. Detroit Reservoir is a popular recreation area for water-based recreation including fishing, boating, water skiing, and swimming and land-based recreation including camping and picnicking. The availability of boating and other water-based recreation is seasonally limited by the planned lower reservoir levels between fall and spring. The reservoir is a designated stop along the Mt. Jefferson Loop of the Oregon Cascades Birding Trail, a self-guided auto tour of nearly 200 prime birding destinations in the Oregon Cascades. The Oregon Cascades Birding Trail is divided into five major loops that run down both sides of the Cascade Mountains covering over 1,000 miles of

[47] Big Cliff Reservoir does not have designated recreational areas with amenities or the associated tracking of recreational value. See Section 3.14.1.2 for more information.

roadways with opportunities to see over 300 species of birds. The Mt. Jefferson Loop is known for its variety in habitat, ranging from dry sagebrush and juniper flats to dense forests and mountain streams. Detroit Reservoir is known for spotting western and horned grebes, common loons, hooded and common mergansers, and gulls with opportunities to see bald eagles and osprey in the spring and summer (The Oregon Birding Trails Working Group No Date). The Detroit Reservoir area provides habitat for songbirds in its hardwood stands and osprey use lakeshore snags and trees as roosts (places to rest or sleep) and nesting sites (USACE 2020e; USACE No Date-e). Visitors to the reservoir can fish for trout and kokanee using shore, motorized boat, float tube, fly, spin, and bait fishing methods. The reservoir is typically stocked with one-pound hatchery trout. Harvesting Chinook in the reservoir is prohibited and any Chinook accidentally caught must be released unharmed (USFS 2021; ODFW 2021b).

The managing agency, the months available, and many of the activities and amenities available at each recreation area are included below in Table 3.14-1. The recreation sites are shown below in Figure 3.14-1. Recreation sites operated by USFS include Upper Arm Day Use, Detroit Flats Day Use, Santiam Flats Campground, Hoover Campground, Piety Island Campground, Cove Creek Campground, and Southshore Campground. The Upper Arm Day Use Area is located in a quiet cove of the Breitenbush Arm of the Detroit Reservoir where visitors can fish along the shoreline trails or from the wooden fishing pier. The Upper Arm Day Use Area is closed for the 2021 season for reconstruction after damage from the Beachie Creek and Lionshead Fire. The Detroit Flats Day Use Area offers picnicking, kayaking, swimming, boating, and water skiing. The Santiam Flats Campground, located at the confluence of the North Santiam River along the shore of the reservoir, consists of 32 campsites with fishing, boating, and hiking at nearby trails. Hoover Campground is located at an elevation of 1,600 feet on the shore of the reservoir. The campground includes an interpretive trail and has campfire rings, picnic tables, and more. Piety Island Campground has boat-in access from the northeast side of the island and sites are available on a walk-in basis. The campground is closed for the 2021 season as a result of damage from the Beachie Creek Fire. Cove Creek Campground, the largest USFS campground on Detroit Reservoir, consists of 63 camp sites. Southshore Campground is located on the south shore, further away from the busier portions of the reservoir, and offers 25 campsites (USFS 2021).

Mongold Day Use and Detroit Lake State Park are operated by OPRD. Mongold Day Use is located along the forested shores of the reservoir and offers year-round boating access, including a paved boat ramp, swim area with a grassy beach, picnic area, and over 80 parking spots. Detroit Lake State Park offers 300 camping sites, some of which are full-hookup sites (sewer, electricity, and water). The state park also has parking, picnic tables, fire rings, showers, and swimming areas (OPRD 2020). Two privately owned marinas, Detroit Lake Marina and Kane's Marina, are located on the reservoir near the town of Detroit. The Detroit Lake Marina includes a food and supply store and rentable boats, canoes, kayaks, and jet skis as well as a food vender, shower, parking, gas dock, and guest tie up dock (Detroit Lake Marina 2021). Kane's Marina is equipped with boat moorage and rentals, an RV park and day use area, fishing licenses and supplies, and a rustic tavern (Kane's Marina No Date).

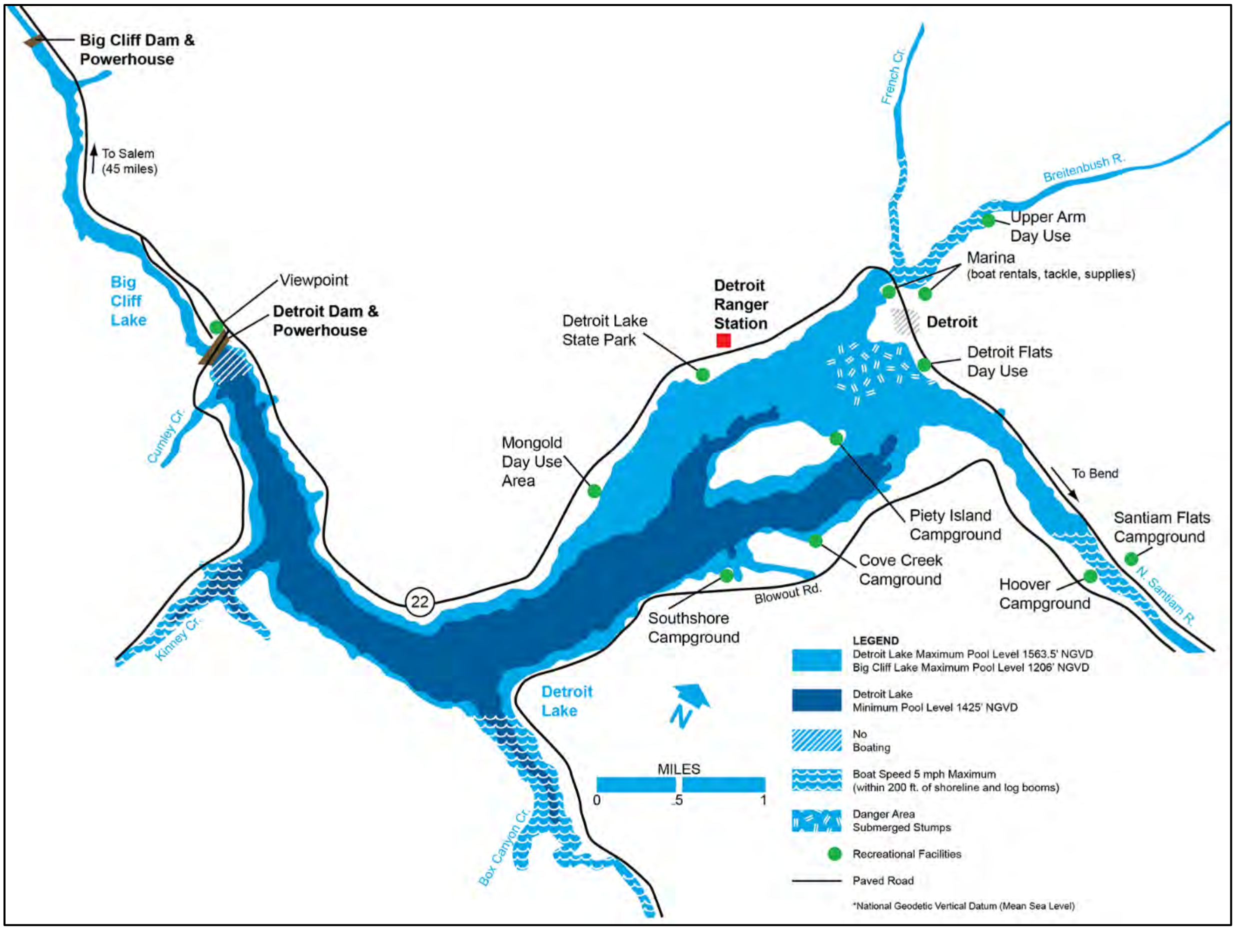


**Figure 3.14-1. Map of Recreation Sites at Detroit and Big Cliff**

Source: USACE No Date-e

The activities and amenities available at each of these recreation sites are summarized below in Table 3.14-1.

**Table 3.14-1. Recreation Areas, Activities, and Amenities at Detroit Dam and Reservoir**

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mongold Day Use | OPRD | All Year | ✓ | ✓ | | | | ✓ | | | | ✓ | ✓ | | | |
| Detroit Lake State Park | OPRD | All Year | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Upper Arm Day Use | USFS | All Year | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | ✓ | | | | |
| Detroit Flats Day Use | USFS | All Year | ✓ | ✓ | | ✓ | ✓ | | | | | | | | | |
| Santiam Flats Campground | USFS | May - Sept | ✓ | ✓ | | | | | ✓ | | ✓ | ✓ | | | | |
| Hoover Campground | USFS | May - Sept | ✓ | ✓ | | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ | | | |
| Piety Island Campground | USFS | All Year | | ✓ | | | | | ✓ | | | ✓ | | | | |
| Cove Creek Campground | USFS | May - Sept | ✓ | ✓ | | | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | | |
| Southshore Campground | USFS | May - Sept | ✓ | ✓ | | | ✓ | | ✓ | | ✓ | ✓ | ✓ | | | |
| Detroit Lake Marina | Private | May - Sept | | ✓ | | | | | | | | | | ✓ | ✓ | |
| Kane's Marina | Private | May - Sept | ✓ | | | | | | | ✓ | | | | | ✓ | |

OPRD = Oregon Parks and Recreation Department; USFS = U.S. Forest Service

Source: USACE 2020e; USACE 2019h; Kane's Marina No Date; Detroit Lake Marina 2021

USACE collects and manages data on annual visitation to each of its projects through the Natural Resources Management Assessment, Operations and Maintenance Business Information Link (OMBIL), Visitation Estimation & Reporting System (VERS), and National Recreation Reservation System (NRRS). A summary of this data is provided for each reservoir in a Value to the Nation Fast Facts report. The data on the number of visits is collected over the Fiscal Year (FY) which begins July 1 and ends June 30. A "visit" is defined as the entry of one person onto a USACE site to engage in one or more recreational activities regardless of the length of stay.

In 2021, visitors to Detroit Reservoir participated most in camping, sightseeing, and angling. Visitation for specific recreation activities in visits (person-days/nights) to Detroit Reservoir is summarized below in Table 3.14-2. All estimated visits in Section 3.14.1 are provided in the units of person-days/nights, which is calculated by dividing the number of annual visitors by the number of days in the recreation season (124 days from May 15 to September 15).

**Table 3.14-2. Visits to Detroit Reservoir, FY 2021**

| Activity | 2021 Estimated Visits[1] |
|---|---|
| Picnickers | 17,524 |
| Campers[2] | 44,961 |
| Swimmers | 15,707 |
| Water Skiers[3] | 15,442 |
| Boaters[3] | 14,533 |
| Sightseers | 40,243 |
| Anglers | 23,649 |
| Hunters | 5,776 |
| Total | 177,836 |

Source: USACE 2016h; USCB 2016; USCB 2021

[1] Estimated adjusted visits are indexed from 2016 to 2021 using data from U.S. Census Bureau 1-Year American Community Survey County level data.

[2] Number of campers are estimated for 2021 using GIS tools and data as well as local, county, and state data as described in Section 1.1 of Technical Appendix K -Recreation.

[3] Number of boaters are estimated for 2021 using regression analysis as described in Section 1.1 of Technical Appendix K -Recreation.

* Note that numbers may not add up exactly due to rounding.

USACE also estimates the recreational value of each USACE project (see Appendix K – Recreation Technical Report). At Detroit Reservoir in 2021, 177,836 annual visits resulted in approximately $1,149,965 of recreational value as shown in below in Table 3.14-3.

**Table 3.14-3. Recreational Value of Detroit Reservoir, FY 2021**

| Description | U.S. Dollars |
|---|---|
| Total Annual Recreational Value | $1,149,965 |

Source: Appendix K

#### *3.14.1.2 Big Cliff (Reregulating)*

Big Cliff Dam and Reservoir is located at river mile 58.1 on the North Santiam River, three miles downstream of Detroit Dam, and is accessible from North Santiam Highway (Oregon Route 22). Since the dam is used to regulate power-generating water releases from Detroit Dam, the water level of Big Cliff Reservoir fluctuates as much as 24 feet daily. Like the Detroit Dam, Big Cliff Dam is a designated stop along the Mt. Jefferson section of the Oregon Cascades Birding

Trail where visitors can see osprey and neotropical migrant songbirds. The boat ramp at Big Cliff Reservoir is permanently closed to vehicle traffic; however, non-motorized boats (i.e., kayaks) are still allowed to launch (USACE No Date-a). Due to its proximity to Detroit Reservoir and the smaller size of Big Cliff Reservoir, recreation at Big Cliff is closely connected to Detroit Reservoir as shown in Figure 3.14-1. As such, Big Cliff Reservoir does not have designated recreational areas with amenities or the associated estimated recreational value.

#### *3.14.1.3 Foster*

Foster Dam is located at river mile 38.5 on the South Santiam River, at the confluence of the South Santiam and Middle Santiam rivers. Recreation sites around Foster Reservoir are accessible via Foster Dam Road off of Santiam Highway (U.S. Highway 20) and other local roads. The 1,800-acre Foster Reservoir area provides habitat for species including the northern spotted owl, steelhead and cutthroat trout, Chinook salmon, the western pond turtle, and several amphibians (USACE No Date-j). Foster Reservoir is typically stocked with trout; however, visitors to the reservoir can also catch smallmouth bass, yellow perch, catfish, bluegill, and crappie (ODFW 2021b)

The managing agency, the months available, and many of the activities and amenities available at each recreation area are included below in Table 3.14-4. The recreation sites are shown below in Figure 3.14-2. USACE operates one day-use park, Andrew S. Wiley Park, which has picnic tables, barbecue grills, and a paved boat ramp with access to the South Santiam River below the dam. Linn County Parks operates several day-use sites, boat ramps, and campgrounds (USACE No Date-j). Lewis Creek Park is an approximately 40-acre day-use area with boarding floats, moorage, picnic areas, and a roped-off swim beach. As of spring 2021, Linn County is conducting public outreach for developing a master plan to upgrade the park and its amenities in response to visitor needs. Shea Point is a viewpoint with a day-use area and access to nearby hiking trails. Calkins Ramp has a two-lane boat ramp and parking for 39 trucks and trailers and 10 additional vehicles. Gedney Creek Ramp has 55 boat parking spaces. Edgewater County Park and Marina has 49 full hookup RV campsites with WiFi connections; 40 boat slips on the reservoir; and boating, fishing and other water-based recreation. Sunnyside Park is a 98-acre campground with picnicking, volleyball, and water-based recreation like water skiing, fishing, and jet skiing. Other amenities include RV hookups, group camping, moorage, group shelters, showers, and a boat ramp, dog park, dump station, and playground. As of spring 2021, Linn County is conducting public outreach for developing a master plan to upgrade the park and its amenities in response to visitor needs (Linn County Parks & Recreation No Date).

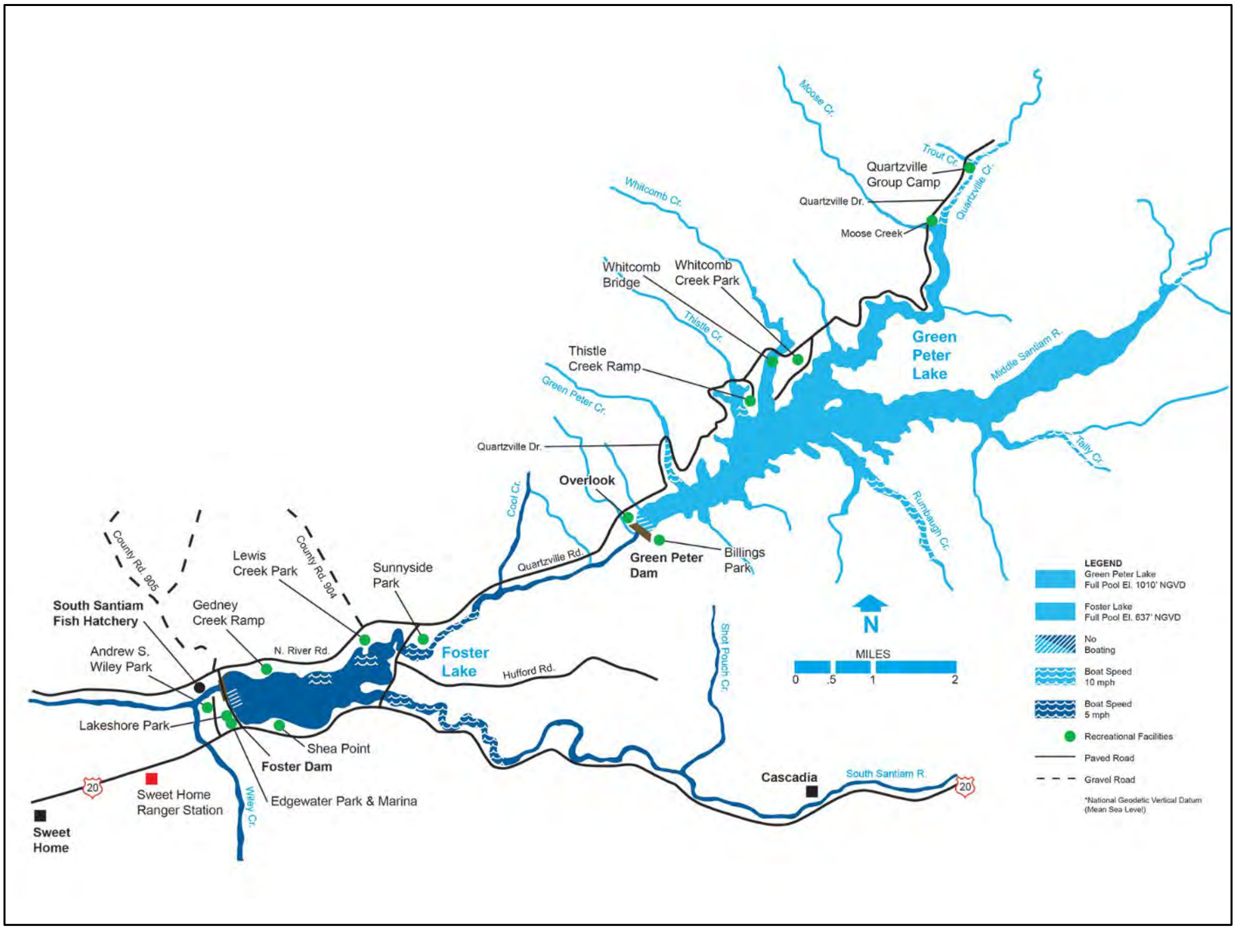


**Figure 3.14-2. Map of Recreation Sites at Foster and Green Peter**

Source: USACE No Date-j

The activities and amenities available at each of these recreation sites are summarized below in Table 3.14-4.

**Table-3.14-4. Recreation Areas, Activities, and Amenities at Foster Dam and Reservoir**

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lakeshore Park Day-Use | Linn County | All Year | ✓ | ✓ | | | | | | | | | | | | |
| Andrew S. Wiley Park | USACE | All Year | ✓ | ✓ | | | | | | | | | ✓ | | | |
| Shea Point | Linn County | All Year | ✓ | ✓ | | ✓ | | | | | | | | | | |
| Calkins Ramp | Linn County | May - Sept | ✓ | ✓ | | | | | | | | | ✓ | | | |
| Gedney Creek Ramp | Linn County | May - Sept | ✓ | ✓ | | | | | | | | | ✓ | | | |
| Lewis Creek Park | Linn County | May - Sept | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | ✓ | | | ✓ | |
| Sunnyside Park | Linn County | All Year | ✓ | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Edgewater Park | Linn County | All Year | | ✓ | | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | |

USACE = U.S. Army Corps of Engineers

Source: USACE 2020f; USACE 2019h

In 2021, Foster Reservoir was the second most visited reservoir out of the 13 USACE reservoirs. Visitors to Foster Reservoir participated most in sightseeing, boating, and angling. Visitation for specific recreation activities at Foster Reservoir is summarized below in Table 3.14-5.

**Table 3.14-5. Visits to Foster Reservoir, FY 2021**

| Activity | 2021 Estimated Visits[1] |
|---|---|
| Picnickers | 52,502 |
| Campers | 10,706 |
| Swimmers | 35,886 |
| Water Skiers | 29,397 |
| Boaters | 92,280 |
| Sightseers | 190,554 |
| Anglers | 67,095 |

| Activity | 2021 Estimated Visits[1] |
|---|---|
| Hunters | 0 |
| Total | 478,419 |

Source: USACE 2016m

[1] Estimated adjusted visits are indexed from 2016 to 2021 using data from U.S. Census Bureau 1-Year American Community Survey County level data. Source: (USCB 2016), (USCB 2021)

* Note that numbers may not add up exactly due to rounding.

At Foster Reservoir in 2021, 478,419 annual visits resulted in approximately $4,043,919 of recreational value as shown in below in Table 3.14-6.

**Table 3.14-6. Recreational Value of Foster Reservoir, FY 2021**

| Description | U.S. Dollars |
|---|---|
| Total Annual Recreational Value | $4,043,919 |

Source: Appendix K

#### *3.14.1.4 Green Peter*

Green Peter Dam and Reservoir is located at river mile 5.5 on the Middle Santiam River, 7 miles upstream of Foster Dam. Recreation sites around Green Peter Reservoir are accessible via Quartzville Drive off of Santiam Highway (U.S. Highway 20) and other local roads. Along with Foster Reservoir, Green Peter Reservoir is a popular recreation destination for fishing, boating, water skiing, swimming, and picnicking. Similar to the other dams and reservoirs, visitors can see osprey nests along the shorelines of the reservoir. USACE works with the ODFW to support resident game and nongame fisheries within the waters of the Middle Santiam River Basin (USACE 2020f; USACE No Date-k). The Green Peter Reservoir is stocked annually with 20,000 hatchery trout and was stocked with an additional 6,250 trout in July of 2021. Anglers at the reservoir can catch up to 25 kokanee per day, unlimited smallmouth bass, and up to five trout per day (ODFW 2021b). See the Fish, Aquatic Invertebrates, and Habitat Section for more information on how fisheries at Green Peter Reservoir are maintained.

The managing agency, the months available, and many of the activities and amenities available at each recreation area are included below in Table 3.14-7. The recreation sites are shown above in Figure 3.14-2. USACE operates two recreation areas at Green Peter: the Dam Overlook and Billings Park. The Dam Overlook is a day-use area located on the southwest corner of the reservoir, on the northwest side of the dam. Billings Park is a simple day-use area located across the dam from the overlook.

Linn County Parks operates several boat ramps, campgrounds, and day-use areas at Green Peter (USACE No Date-k). Thistle Creek Park is a 9.2-acre boat ramp area located on the north shore of the reservoir. The elevations of the upper and lower ramp are 980 feet and 919 feet, respectively. When the water level drops below an elevation of 982-983 feet, boaters are only able to launch from the lower ramp which is accessible all year. Whitcomb Creek Park consists of 328 acres of forest along the reservoir. Visitors to the park and campground enjoy mountain views, bird-watching, sailing, fishing, hiking, camping, and water skiing. Quartzville Group Camp can accommodate up to 50 people with tents and RVs Linn County Parks & Recreation No Date).

**Table 3.14-7. Recreation Areas, Activities, and Amenities at Green Peter Dam and Reservoir**

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thistle Creek Park | Linn County | All Year | ✓ | ✓ | | | | | | | | | ✓ | | | |
| Whitcomb Creek Park | Linn County | May - Oct | ✓ | ✓ | | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ | | | |
| Dam Overlook | USACE | All Year | ✓ | ✓ | | | | | | | | | | | | |
| Billings Park | USACE | All Year | ✓ | ✓ | | | | | | | | | | | | |
| Whitcomb Bridge Day-use | Linn County | All Year | ✓ | ✓ | | | | | | | | | | | | |
| Moose Creek Day-use | Linn County | All Year | ✓ | ✓ | | | | | | | | | | | | |
| Quartzville Group Camp | Linn County | May - Sept | | ✓ | | | | | ✓ | | ✓ | ✓ | | | | |

USACE = U.S. Army Corps of Engineers

Source: USACE 2020f; USACE 2019h

In 2021, visitors to Green Peter Reservoir participated most in sightseeing, angling, and water skiing. Visitation for specific recreation activities in visits) to Green Peter Reservoir is summarized below in Table 3.14-8.

**Table 3.14-8. Visits to Green Peter Reservoir, FY 2021**

| Activity | 2021 Estimated Visits[1] |
|---|---|
| Picnickers | 12,150 |
| Campers | 9,612 |
| Swimmers | 16,270 |
| Water Skiers | 20,282 |
| Boaters | 16,570 |

| Activity | 2021 Estimated Visits[1] |
|---|---|
| Sightseers | 60,338 |
| Anglers | 44,200 |
| Hunters | 1,337 |
| Total | 180,760 |

Source: USACE 2016n; USCB 2016; USCB 2021

[1]Estimated adjusted visits are indexed from 2016 to 2021 using data from U.S. Census Bureau 1-Year American Community Survey County level data.

* Note that numbers may not add up exactly due to rounding.

At Green Peter Reservoir in 2921, 180,760 annual visits are estimated to have resulted in $1,211,913 of recreational value as shown in below in Table 3.14-9.

**Table 3.14-9. Recreational Value of Green Peter Reservoir, FY 2021**

| Description | U.S. Dollars |
|---|---|
| Total Annual Recreational Value | $1,211,913 |

Source: Appendix K

#### *3.14.1.5 Cougar*

Cougar Dam and Reservoir is located at river mile 4.4 of the South Fork McKenzie River, about 42 miles east of Eugene. Recreation sites around Cougar Reservoir are accessible via Aufderheide Drive, accessible off of McKenzie Highway (Oregon Route 126) as well as other local roads. The 5,000-acre area provides recreation opportunities for camping, boating, swimming, fishing, and water skiing. All recreation facilities at the reservoir are within the WNF and are managed by USFS. The reservoir is a designated stop along the Three Sisters section of the Oregon Cascades Birding Trail where visitors can spot American peregrine falcons around the cliffs above the reservoir (USACE No Date-d). There is a large nesting colony of Cliff Swallows southwest of the dam where visitors can also see Violet-green and Northern Rough-winged Swallows. Visitors may also see Rock Wren, Canyon Wren, Bald Eagle, Belted Kingfisher, and waterfowl such as Bufflehead, goldeneyes, and Common and Hooded Mergansers in the fall (The Oregon Birding Trails Working Group No Date).

The managing agency, the months available, and many of the activities and amenities available at each recreation area are included below in Table 3.14-10. The recreation sites are shown below in Figure 3.14-3. All of the recreation sites at Cougar are managed by the USFS. The shaded picnic sites at Echo Park overlook the reservoir. Visitors can hike along the adjacent east fork trail from the lower trailhead. The Slide Creek Campground on the east side of the reservoir near the Slide Creek Day Use Area offers access to fishing, boating, swimming, and water skiing. The 13 campsites at Sunnyside Campground are located amongst a large grove of conifers and have easy access to the nearby creek, river, and lake. French Pete Campground has hiking trails nearby. Delta Campground is a 38-site campground known for its access to rafting and fishing on the McKenzie River. The campground is near nature trails and Terwilliger Hot Springs. As of August 2021, the Delta Campground is closed due to the Holiday Farm Fire wildfire. Cougar Crossing is located on the southern shore of the reservoir and includes a day-use area with camping and a boat launch (USFS 2021).

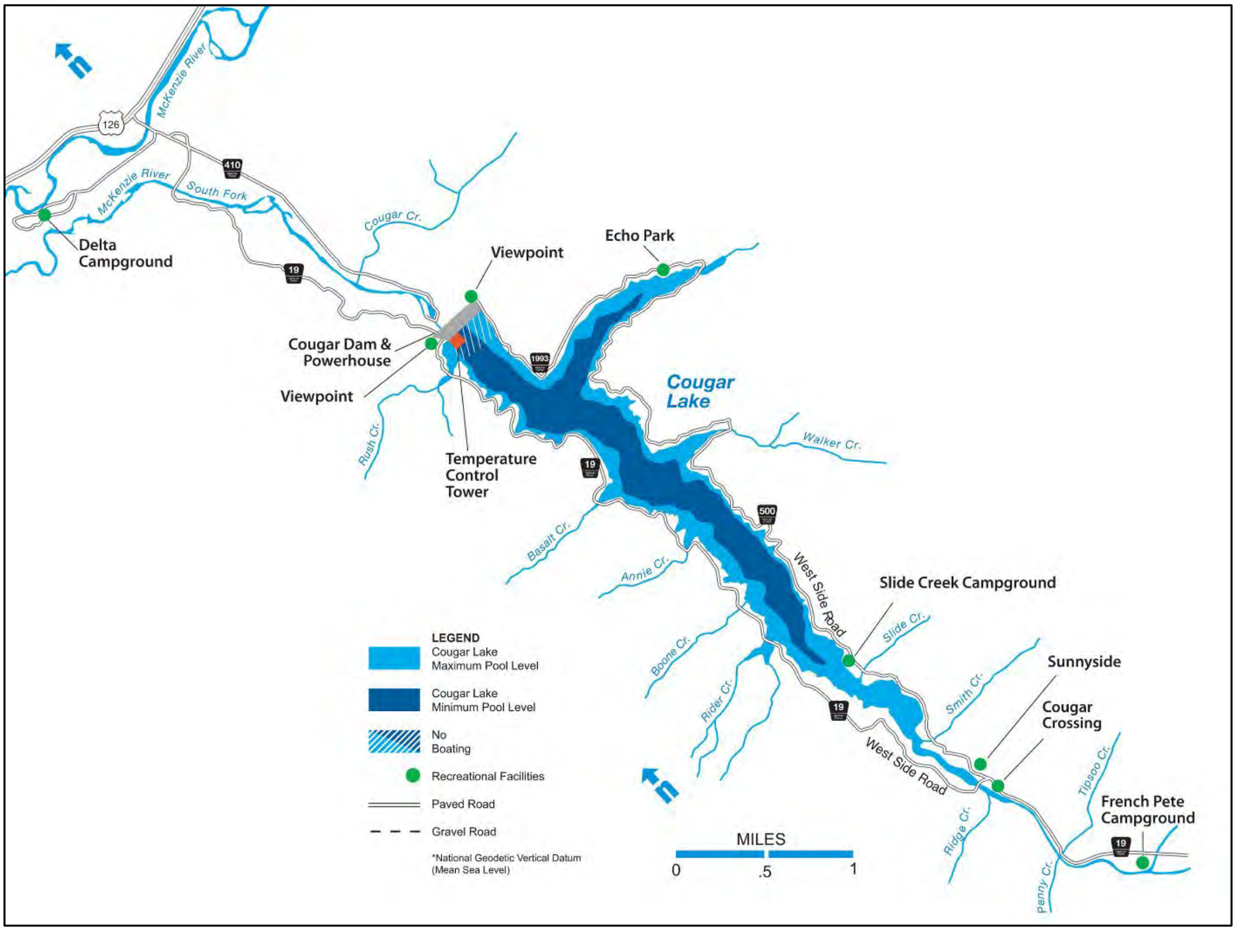


**Figure 3.14-3. Map of Recreation Sites at Cougar**

Source: USACE No Date-d

The activities and amenities available at each of these recreation sites are summarized below in Table 3.14-10.

**Table 3.14-10. Recreation Areas, Activities, and Amenities at Cougar Dam and Reservoir**

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Echo Park | USFS | April - Sept | ✓ | ✓ | | ✓ | | | | | | ✓ | ✓ | | | |
| Slide Creek Campground | USFS | May - Sept | ✓ | ✓ | | | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | | |
| Sunnyside Campground | USFS | May - Sept | | ✓ | | | | | ✓ | | ✓ | ✓ | | | | |
| French Pete Campground | USFS | May - Sept | | ✓ | | ✓ | ✓ | | ✓ | | ✓ | ✓ | | | | |
| Delta Campground | USFS | April - Oct | ✓ | ✓ | | ✓ | ✓ | | ✓ | | ✓ | ✓ | | | | |
| Cougar Crossing | USFS | All Year | ✓ | ✓ | | | | | ✓ | | ✓ | ✓ | ✓ | | | |

USFS = U.S. Forest Service

Source: USACE 2019h; USACE 2009c

In 2019, visitors to Cougar Reservoir participated most in sightseeing, angling, and picnicking. Visitation for specific recreation activities in visits to Cougar Reservoir is summarized below in Table 3.14-11.

**Table 3.14-11. Visits to Cougar Reservoir, FY 2021**

| Activity | 2021 Estimated Visits[1] |
|---|---|
| Picnickers | 6,184 |
| Campers [2] | 3,265 |
| Swimmers | 4,053 |
| Water Skiers | 3,213 |
| Boaters [3] | 4,588 |
| Sightseers | 19,110 |
| Anglers | 8,400 |
| Hunters | 1,147 |
| Total | 49,959 |

Source: USACE 2016g; USCB 2016; USCB 2021

[1] Estimated adjusted visits are indexed from 2016 to 2021 using data from U.S. Census Bureau 1-Year American Community Survey County level data.

[2] Number of campers are estimated for 2021 using GIS tools and data as well as local, county, and state data as described in Section 1.1 of Technical Appendix K -Recreation.

[3] Number of boaters are estimated for 2021 using regression analysis as described in Section 1.1 of Technical Appendix K -Recreation.

* Note that numbers may not add up exactly due to rounding.

At Cougar Reservoir in 2021, 49,959 annual visits resulted in approximately $325,413 of recreational value as shown in below in Table 3.14-12.

**Table 3.14-12. Recreational Value of Cougar Reservoir, FY 2021**

| Description | U.S. Dollars |
|---|---|
| Total Annual Recreational Value | $325,413 |

Source: Appendix K

### *3.14.1.6 Blue River*

Blue River Dam and Reservoir is located at river mile 2 on the Blue River, a tributary of the McKenzie River, about 38 miles east of Eugene, Oregon. Recreation sites around Blue River Reservoir are accessible via Lucky Boy Road, which is accessible off of McKenzie Highway (Oregon Route 126) as well as other local roads. Visitors can see osprey, who use large trees and snags around the reservoir for roosts (places to rest or sleep). The reservoir is also home to several rare species including bull trout, Chinook salmon, and western pond turtles. USACE works with the ODFW to support resident game and nongame fisheries within the waters of the Blue River Reservoir. Anglers at the reservoir can catch warm water species of trout. In May of 2021, the reservoir was stocked with 1,500 legal-size and 50 trophy-size rainbow trout (ODFW 2021b). See the Fish, Aquatic Invertebrates, and Habitat Section for more information on how fisheries at Blue River Reservoir are maintained. The entire 1,600-acre reservoir area is located within the WNF, and the recreational facilities are operated by USFS (USACE No Date-b).

The managing agency, the months available, and many of the activities and amenities available at each recreation area are included below in Table 3.14-13. The recreation sites are shown below in Figure 3.14-4. USFS operates three recreation sites at Blue River. Mona Campground is located in a long, narrow strip of mixed conifers and is a popular destination for water-based recreation. The campground has 23 sites with tables, fire rings, drinking water, and firewood. Lookout Campground is located on an open meadow and has picnic sites, a boat launch, floating dock, and a day use/overflow parking area. The campground does not have any designated sites, but can accommodate up to 20 single camp sites. The campground has tables, fire rings, drinking water, and firewood. Saddle Dam Ramp is a natural boat ramp on an old access road USACE used when building the Blue River and Saddle Dams. The boat ramp is typically closed from mid-October to mid-March or when the reservoir level dips below 1,295 feet. Open and close dates may be earlier or later depending on water level fluctuation.

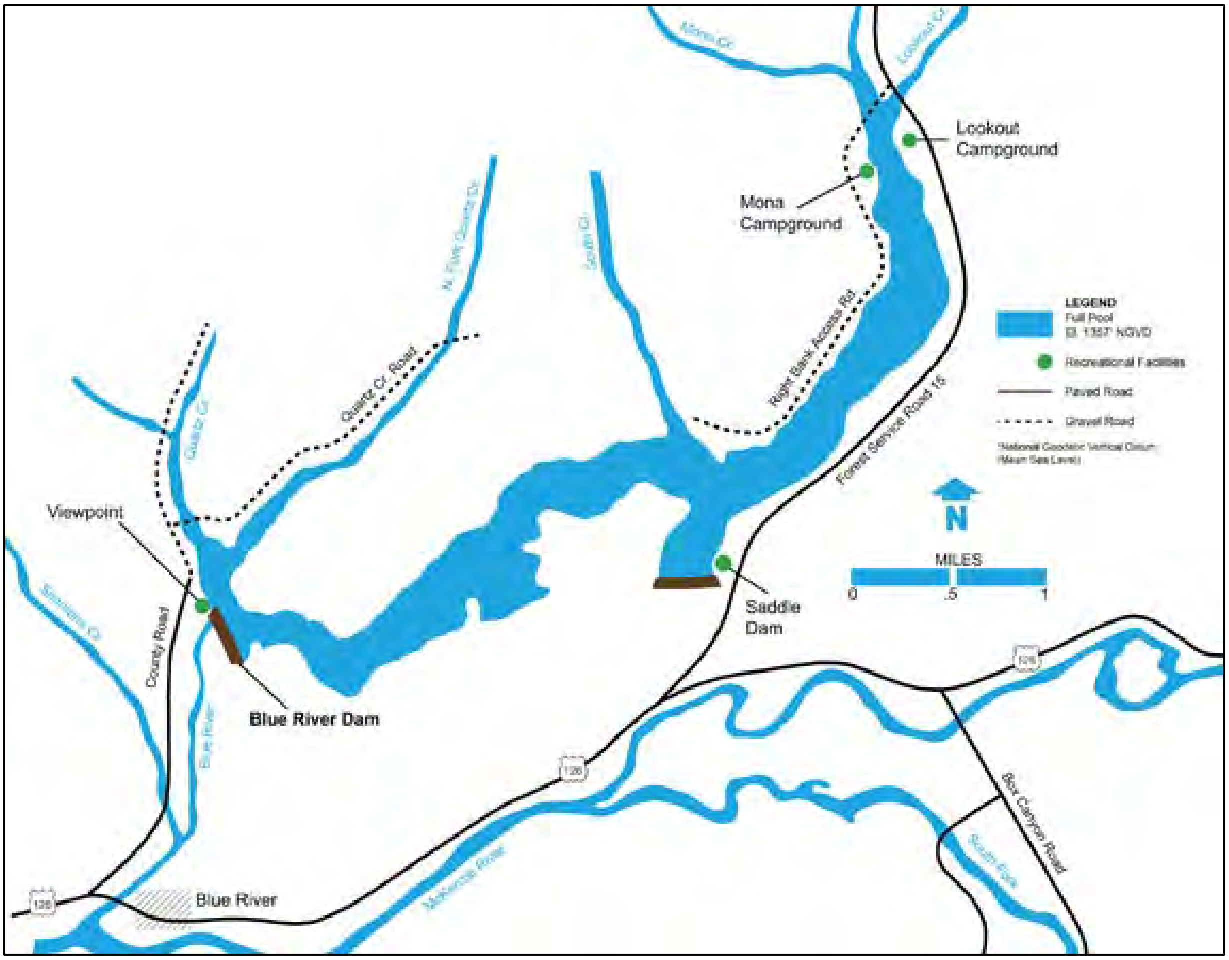


**Figure 3.14-4. Map of Recreation Sites at Blue River**

Source: USACE No Date-b

**Table 3.14-13. Recreation Areas, Activities, and Amenities at Blue River Dam and Reservoir**

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mona Campground | USFS | May - Sept | | ✓ | | | ✓ | | ✓ | | ✓ | ✓ | | | | |
| Lookout Campground | USFS | All Year | ✓ | ✓ | | | ✓ | | ✓ | | ✓ | ✓ | ✓ | | | |

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Saddle Dam Ramp | USFS | April - Oct | ✓ | ✓ | | | | | | | | ✓ | ✓ | | | |

USFS = U.S. Forest Service

Source: USACE 2019h; USACE 2009c

In 2021, visitors participated most in sightseeing, camping, and angling. Visitation for specific recreation activities at Blue River Reservoir is summarized below in Table 3.14-14.

**Table 3.14-14. Visits to Blue River Reservoir, FY 2021**

| Activity | 2021 Estimated Visits[1] |
|---|---|
| Picnickers | 1,557 |
| Campers[2] | 4,652 |
| Swimmers | 650 |
| Water Skiers | 676 |
| Boaters | 712 |
| Sightseers | 8,330 |
| Anglers | 3,297 |
| Hunters | 444 |
| Total | 20,318 |

Source: USACE 2016e; USCB 2016; USCB 2021

[1] Estimated adjusted visits are indexed from 2016 to 2021 using data from U.S. Census Bureau 1-Year American Community Survey County level data.

[2] Number of campers are estimated for 2021 using GIS tools and data as well as local, county, and state data as described in Section 1.1 of Technical Appendix K -Recreation.

* Note that numbers may not add up exactly due to rounding.

At Blue River Reservoir in 2021, 20,318 annual visits are estimated to have resulted in $124,055 of recreational value as shown in below in Table 3.14-15.

**Table 3.14-15. Recreational Value of Blue River Reservoir, FY 2021**

| Description | U.S. Dollars |
|---|---|
| Total Annual Recreational Value | $124,055 |

Source: Appendix K

### *3.14.1.7 Lookout Point*

Lookout Point Dam and Reservoir is located at river mile 21.3 on the Middle Fork Willamette River, about 22 miles southeast of Eugene, Oregon. Recreation sites around Lookout Point Reservoir are accessible via local roads off of Willamette Highway (Oregon Route 58). The 7,800-acre reservoir area overlaps with the WNF; the surrounding recreational areas are operated by USFS. Lookout Point is a popular recreation destination for fishing, boating, water skiing, swimming, picnicking, and hunting. The reservoir's shoreline provides habitat for rare species, including northern spotted owl, western pond turtles, Chinook salmon, and Oregon chub; most notably, bald eagles winter and regularly nest at Lookout Point (USACE No Date-m).

The managing agency, the months available, and many of the activities and amenities available at each recreation area are included below in Table 3.14-16. The recreation sites are shown below in Figure 3.14-5. USACE operates one day-use park (Meridian Park), one day-use boat ramp (Signal Point Ramp), and one campground (Ivan Oakes). Meridian Park includes a gravel road and parking area, picnic tables, and a boat ramp with a courtesy dock; however, access to the ramp is limited by seasonal water levels. Signal Point Ramp has a day-use area, access to nearby hiking trails, and a boat launch. The water southeast of the ramp area is known to be a hazardous stump area (submerged tree stumps pose a collision hazard to boaters). Ivan Oakes campground has direct access to the reservoir for water-based recreation.

USFS operates two campgrounds: Hampton Campground and Black Canyon Campground. Hampton Campground is located in an open area near the reservoir with few trees dotting the shoreline. Camping, boating, and fishing are available; however, the campground is adjacent to a railroad which is active at all hours. Black Canyon Campground is located along the middle Fork Willamette River where visitors can fish and have picnics.

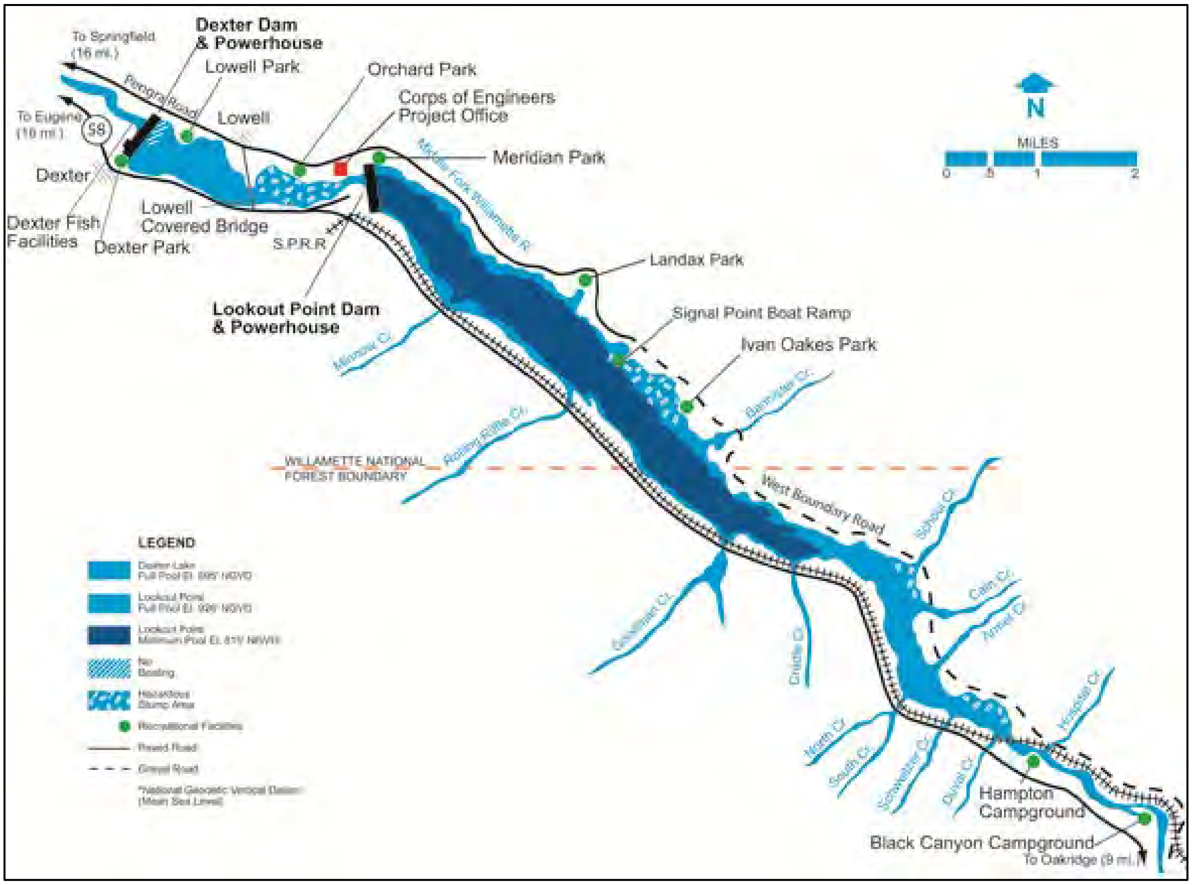


**Figure 3.14-5. Map of Recreation Sites at Lookout Point and Dexter**

Source: USACE No Date-m

The activities and amenities available at each of these recreation sites are summarized below in Table 3.14-16.

**Table 3.14-16. Recreation Areas, Activities, and Amenities at Lookout Point Dam and Reservoir**

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Meridian Park | USACE | May - Sept | ✓ | ✓ | | ✓ | | | | | | | ✓ | | | |
| Ivan Oakes Campground | USACE | May - Sept | | ✓ | | ✓ | ✓ | | ✓ | | | ✓ | | | | |

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Signal Point Ramp | USACE | All Year | ✓ | ✓ | | ✓ | | | | | | | ✓ | | | |
| Hampton Campground | USFS | May - Sept | ✓ | ✓ | | | | | ✓ | | | ✓ | ✓ | | | |
| Black Canyon Campground | USFS | May - Sept | ✓ | ✓ | | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ | | | |

USACE = U.S. Army Corps of Engineers; USFS = U.S. Forest Service

Source: USACE 2019h; USACE 2009h

In 2021, visitors to Lookout Point Reservoir participated most in angling, swimming, and picnicking. Visitation for specific recreation activities at Lookout Point Reservoir is summarized below in Table 3.14-17.

**Table 3.14-17. Visits to Lookout Point Reservoir, FY 2021**

| Activity | 2021 Estimated Visits[1] |
|---|---|
| Picnickers | 14,386 |
| Campers[2] | 2,938 |
| Swimmers | 19,683 |
| Water Skiers | 8,679 |
| Boaters | 10,601 |
| Sightseers | 13,130 |
| Anglers | 31,121 |
| Hunters | 533 |
| Total | 101,072 |

Source: USACE 2016; USCB 2016; USCB 2021

[1] Estimated adjusted visits are indexed from 2016 to 2021 using data from U.S. Census Bureau 1-Year American Community Survey County level data.

[2] Number of campers are estimated for 2021 using GIS tools and data as well as local, county, and state data as described in Section 1.1 of Technical Appendix K -Recreation. * Note that numbers may not add up exactly due to rounding.

At Lookout Point Reservoir in 2021, 101,072 annual visits resulted in approximately $750,891 of recreational value as shown in below in Table 3.14-18.

**Table 3.14-18. Recreational Value of Lookout Point Reservoir, FY 2021**

| Description | U.S. Dollars |
|---|---|
| Total Annual Recreational Value | $750,891 |

Source: Appendix K

### *3.14.1.8 Hills Creek*

Hills Creek Dam is located at river mile 47.8 on the Middle Fork Willamette River. Recreation sites around Hills Creek Reservoir are accessible via local roads off of Willamette Highway (Oregon Route 58). The 2,735-acre reservoir and its 44 miles of forested shoreline make Hills Creek a popular destination for camping, boating, swimming, fishing, and water skiing. All recreation facilities are within the WNF and as such are operated by USFS (USACE 2009g). Hills Creek is a designated stop along the Three Sisters section of the Oregon Cascades Birding Trail (USACE No Date-l). Visitors to Hills Creek Reservoir can catch trout, crappie, and bass. The reservoir is typically stocked with legal-size rainbow trout, 60,000 adipose fin-clipped (clipped between the tail and dorsal fin to enable anglers to identify their catch as a stocked fish) rainbow trout fingerlings, and 100,000 adipose fin-clipped spring Chinook salmon fingerlings annually. Trout and salmon must be adipose-fin clipped to be harvested at the reservoir (ODFW 2021b).

The managing agency, the months available, and many of the activities and amenities available at each recreation area are included below in Table 3.14-19. The recreation sites are shown below in Figure 3.14-6. The boat ramp, picnicking sites, and camping sites at Hills Creek are all operated by USFS. Bingham Boat Ramp is a small, day use only launch located at the south end of the reservoir. The ramp requires higher reservoir levels to be accessible by boat, whereas the Packard boat launch (near the Packard Creek Campground) is usually accessible year- round. Cline-Clark Picnic Area is located on the shore of the reservoir. In addition to picnicking with views of the reservoir, visitors can fish for crappie, largemouth bass, brown bullhead, catfish, and rainbow and cutthroat trout. C.T. Beach Picnic Area has two picnic tables and one fire ring. Sand Prairie Campground has 21 sites. Visitors are able to access the 27-mile Middle Fork Willamette Trail from the Sand Prairie Campground for hiking, horseback riding, and mountain biking. Packard Creek Campground has 37 sites with great views of the reservoir. Each campsite has a picnic table and campfire ring. Visitors can swim, boat, and fish and access the nearby Larison Creek Trail to hike, horseback ride, and mountain bike.

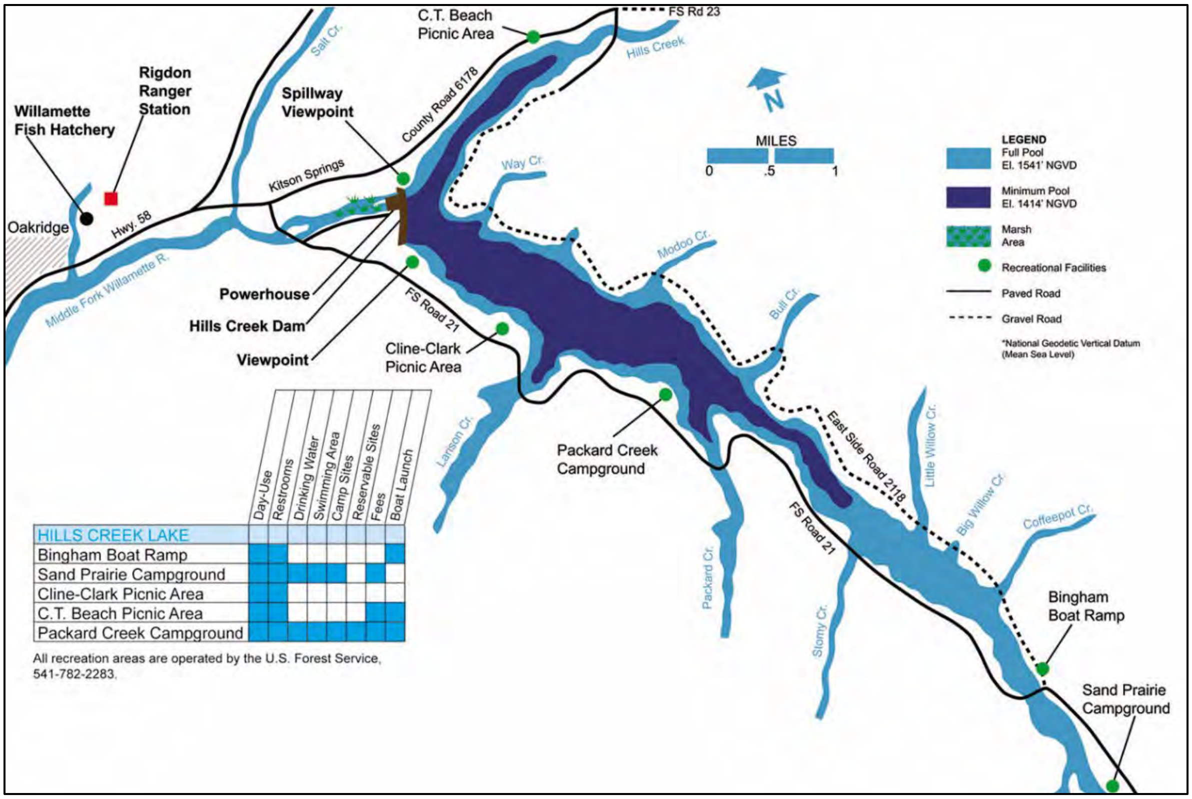


**Figure 3.14-6. Map of Recreation Sites at Hills Creek**

Source: USACE No Date-l

The activities and amenities available at each of these recreation sites are summarized below in Table 3.14-19.

**Table 3.14-19. Recreation Areas, Activities, and Amenities at Hills Creek Dam and Reservoir**

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bingham Boat Ramp | USFS | All Year | ✓ | ✓ | | | | | | | | | ✓ | | | |
| Sand Prairie Campground | USFS | May - Sept | ✓ | ✓ | | | | | ✓ | | | ✓ | | | | |
| Cline-Clark Picnic Area | USFS | All Year | ✓ | ✓ | | | | | | | | | | | | |

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C.T. Beach Picnic Area | USFS | All Year | ✓ | ✓ | | | | | | | | ✓ | ✓ | | | |
| Packard Creek Campground | USFS | April - Sept | ✓ | ✓ | | | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | | |

USFS = U.S. Forest Service

Source: USACE 2019h; USACE 2009g

In 2021, visitors to Hills Creek Reservoir participated most in camping, water skiing, and boating. Visitation for specific recreation activities at Hills Creek Reservoir is summarized below in Table 3.14-20.

**Table 3.14-20. Visits to Hills Creek Reservoir, FY 2021**

| Activity | 2021 Estimated Visits[1] |
|---|---|
| Picnickers | 55 |
| Campers[2] | 23,015 |
| Swimmers | 8 |
| Water Skiers[3] | 11,554 |
| Boaters[3] | 11,059 |
| Sightseers | 1,070 |
| Anglers | 347 |
| Hunters | 1 |
| Total | 47,110 |

Source: USACE 2016o; USCB 2016; USCB 2021

[1] Estimated adjusted visits are indexed from 2016 to 2021 using data from U.S. Census Bureau 1-Year American Community Survey County level data.

[2] Number of campers are estimated for 2021 using GIS tools and data as well as local, county, and state data as described in Section 1.1 of Technical Appendix K -Recreation.

[3] Number of boaters and water skiers are estimated for 2021 using regression analysis as described in Section 1.1 of Technical Appendix K -Recreation.

* Note that numbers may not add up exactly due to rounding.

At Hills Creek Reservoir in 2021, 47,110 annual visits resulted in approximately $290,933 of recreational value as shown in below in Table 3.14-21.

**Table 3.14-21. Recreational Value of Hills Creek Reservoir, FY 2021**

| Description | U.S. Dollars |
|---|---|
| Total Annual Recreational Value | $290,933 |

Source: Appendix K

### *3.14.1.9 Dexter (Reregulating)*

Dexter Dam and Reservoir is located at river mile 18 on the Middle Fork of the Willamette River, about 22 miles southeast of Eugene. Recreation sites around Dexter Reservoir are accessible via local roads off of Willamette Highway (Oregon Route 58). The 1,300 acres of water and shoreline lands provides habitat for waterfowl, upland game birds, song birds, bald eagles, osprey, black-tailed deer, wintering elk, and other species (USACE 2009h; USACE No Date-f). Dexter is a designated stop along the McKenzie Loop of the Willamette Valley Birding Trail where visitors can see migratory and resident songbirds, osprey and eagles along the northeast shoreline (USACE No Date-f). The Willamette Valley Birding Trail is a self-guided driving tour around the Cascade Mountains that is divided into 12 major loops highlighting 138 birding hotspots (Oregon Birding Trails No Date). The reservoir is typically stocked with rainbow trout, but anglers can also catch largemouth and smallmouth bass (ODFW 2021b).

The managing agency, the months available, and many of the activities and amenities available at each recreation area are included below in Table 3.14-22. USACE operates a boat launch (Middle Fork Boat Launch), fishing area (South Side Fishing Area), and a day-use park (Orchard Park). Visitors can catch trout and salmon in the South Side Fishing Area. Orchard Park is located on the north shore of the reservoir between Dexter Dam and Lookout Point Dam. The park's day use area has picnic tables with a view of Lowell Covered Bridge.

OPRD operates two day-use areas at Dexter: Dexter State Park and Lowell State Park. Dexter State Park has docks, a two-lane launch ramp, and a picnic area that overlooks the reservoir. The park is near an 18-hole disc golf course and is connected to Elijah Bristow State Park through a system of trails that follow the Middle Fork of the Willamette River. Lowell State Park has a picnic shelter that overlooks the reservoir, a wooded picnic area, playground, basketball court, a swim beach, a marina with rentable moorage, a large courtesy dock, and a four-lane launch ramp. The Oregon Association of Rowers and the University of Oregon have boathouses at the park, and host Regattas (rowing races) each spring (OPRD No Date). These recreation sites are shown above in Figure 3.14-5.

**Table 3.14-22. Recreation Areas, Activities, and Amenities at Dexter Dam and Reservoir**

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dexter State Park | OPRD | All Year | ✓ | ✓ | | ✓ | | | | | | | ✓ | | | |
| Lowell State Park | OPRD | All Year | ✓ | ✓ | ✓ | | ✓ | ✓ | | | | | ✓ | | ✓ | |
| Middle Fork Boat Launch | USACE | All Year | ✓ | ✓ | | | | | | | | | ✓ | | | |
| South Side Fishing Area | USACE | All Year | ✓ | ✓ | | | | | | | | | | | | |
| Orchard Park | USACE | May - Sept | ✓ | ✓ | | | | | | | | | | | | |

OPRD = Oregon Parks and Recreation Department; USACE = U.S. Army Corps of Engineers

Source: USACE 2019h; USACE 2009h

In 2021, visitors to Dexter Reservoir participated most in angling, boating, and water skiing. Visitation for specific recreation activities at Dexter Reservoir is summarized below in Table 3.14-23.

**Table 3.14-23. Visits to Dexter Reservoir, FY 2021**

| Activity | 2021 Estimated Visits[1] |
|---|---|
| Picnickers | 34,088 |
| Campers | 0 |
| Swimmers | 30,703 |
| Water Skiers | 42,013 |
| Boaters | 50,840 |
| Sightseers | 29,425 |
| Anglers | 69,975 |
| Hunters | 1,930 |
| Total | 258,974 |

Source: USACE 2016i; USCB 2016; USCB 2021

[1] Estimated adjusted visits are indexed from 2016 to 2021 using data from U.S. Census Bureau 1-Year American Community Survey County level data.

* Note that numbers may not add up exactly due to rounding.

At Dexter Reservoir in 2021, 258,974 annual visits resulted in approximately $1,646,266 of recreational value as shown in below in Table 3.14-24.

**Table 3.14-24. Recreational Value of Dexter Reservoir, FY 2021**

| Description | Economic Impact |
| --- | --- |
| Total Annual Recreational Value | $1,646,266 |

Source: Appendix K

#### *3.14.1.10 Fall Creek*

Fall Creek Dam is at river mile 7.2 on the Fall Creek tributary of the Willamette River and is about 20 miles southeast of Eugene, Oregon. Recreation sites around Fall Creek Reservoir are accessible via local roads off of Willamette Highway (Oregon Route 58). The 1,582-acre reservoir and its 22 miles of forested shoreline provide habitat to a wide variety of wildlife including waterfowl, upland game birds, song birds, bald eagles, osprey, black-tailed deer and other species and makes Fall Creek a popular destination for fishing, boating, water skiing, swimming, camping, and picnicking (USACE No Date-h). Fall Creek Reservoir is stocked with legal-size and pound-size rainbow trout which can be caught all year; however, the use of bait, lures, or artificial flies are seasonally restricted. Visitors are permitted to catch five hatchery trout and an additional two wild trout daily. Fishing for salmon upstream of the dam is prohibited, but downstream of the dam, hatchery Chinook, hatchery steelhead, and wild steelhead greater than 24 inches can be harvested all year (ODFW 2021b).

The managing agency, the months available, and many of the activities and amenities available at each recreation area are included below in Table 3.14-25. The recreation sites are shown below in Figure 3.14-7. USACE operates one day-use park (Tufti Park) which includes a minimally developed day use area with a gravel parking lot, access to the Fall Creek below the dam, and a hiking trail. OPRD operates five day-use areas (Winberry Park, North Shore Park, Free Meadow, and Lakeside One and Two) and two campgrounds (Cascara Campground and Fisherman's Pt. Group Campground). Winberry Park has a two-lane boat ramp, parking for more than 100 cars and 150 boat trailers, a swim dock and swim beach, and picnic areas with barbecue grills and fire rings. North Shore Park has high- and low-water ramps and a picnic area overlooking the reservoir. Cascara Campground has 39 campsites, a boat ramp, and a swim area. Fisherman's Pt. Group Campground is a primitive group site with a 64-person capacity along the shore of the reservoir (OPRD No Date). Sky Camp is a 100-acre private campground operated by the Springfield School District and used for educational purposes. It includes a main lodge with a kitchen and cabins with 164 total beds (USACE No Date-h; Sky Camp No Date).

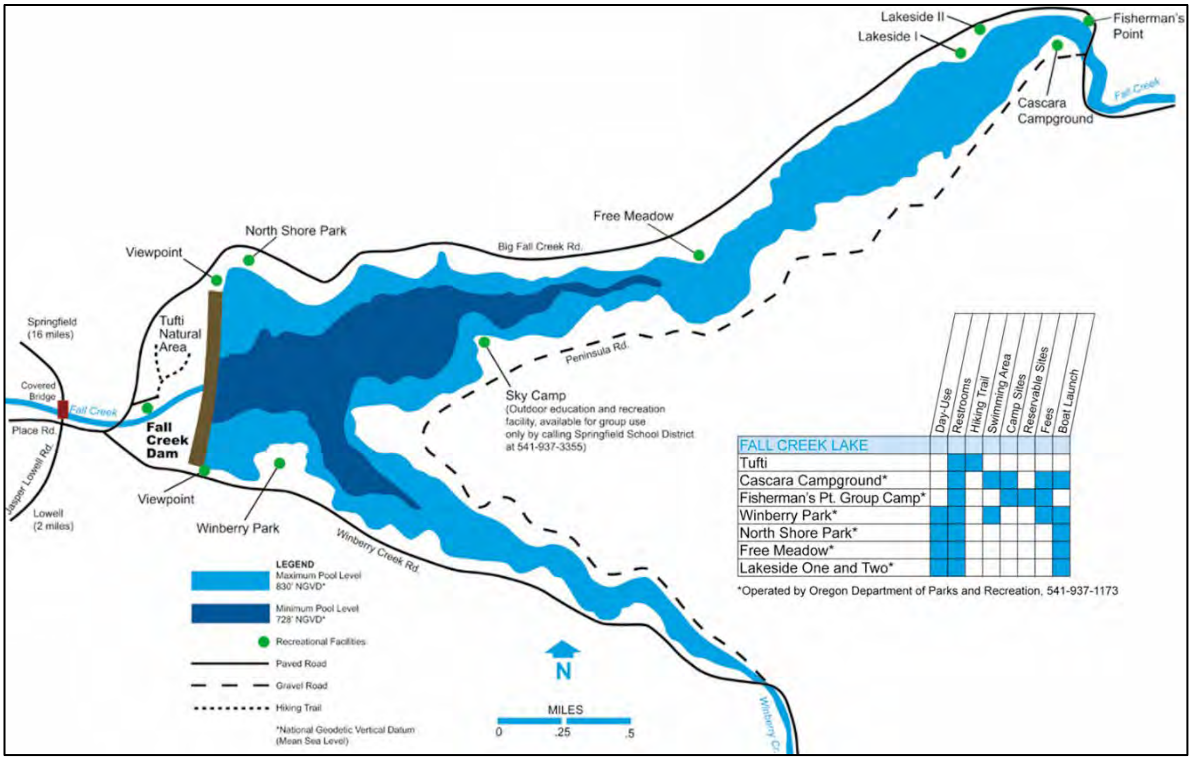


**Figure 3.14-7. Map of Recreation Sites at Fall Creek**

Source: USACE No Date-h

The activities and amenities available at each of these recreation sites are summarized below in Table 3.14-25.

**Table 3.14-25. Recreation Areas, Activities, and Amenities at Fall Creek Dam and Reservoir**

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tufti Park | USACE | All Year | ✓ | ✓ | | ✓ | | | | | | | | | | |
| Cascara Campground | OPRD | May - Sept | | ✓ | | | ✓ | ✓ | ✓ | | | ✓ | ✓ | | | |
| Fisherman's Pt. Group Campground | OPRD | May - Sept | | ✓ | | | ✓ | | ✓ | | ✓ | ✓ | | | | |
| Winberry Park | OPRD | May - Sept | ✓ | ✓ | | | | ✓ | | | | ✓ | ✓ | | | |

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| North Shore Park | OPRD | April - Sept | ✓ | ✓ | | | | | | | | | ✓ | | | |
| Free Meadow | OPRD | May - Sept | ✓ | ✓ | | | | | | | | | | | | |
| Sky Camp | Springfield School | All Year | | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | ✓ | | |
| Lakeside One and Two | OPRD | May - Sept | ✓ | ✓ | | | | | | | | | | | | |

OPRD = Oregon Parks and Recreation Department; USACE = U.S. Army Corps of Engineers

Source: USACE 2019h; USACE 2009e

In 2021, visitors to Fall Creek Reservoir participated most in swimming, water skiing, and picnicking. Visitation for specific recreation activities at Fall Creek Reservoir is summarized below in Table 3.14-26.

**Table 3.14-26. Visits to Fall Creek Reservoir, FY 2021**

| Activity | 2021 Estimated Visits[1] |
|---|---|
| Picnickers | 44,677 |
| Campers[2] | 3,839 |
| Swimmers | 62,312 |
| Water Skiers | 49,356 |
| Boaters | 34,509 |
| Sightseers | 3,940 |
| Anglers | 27,878 |
| Hunters | 20 |
| Total | 226,529 |

Source: USACE 2016k; USCB 2016; USCB 2021

[1] Estimated adjusted visits are indexed from 2016 to 2021 using data from U.S. Census Bureau 1-Year American Community Survey County level data.

[2] Number of campers are estimated for 2021 using GIS tools and data as well as local, county, and state data as described in Section 1.1 of Technical Appendix K -Recreation.

* Note that numbers may not add up exactly due to rounding.

At Fall Creek Reservoir in 2021, 226,529 annual visits resulted in approximately $1,516,584 of recreational value as shown in below in Table 3.14-27.

**Table 3.14-27. Recreational Value of Fall Creek Reservoir, FY 2021**

| Description | U.S. Dollars |
|---|---|
| Total Annual Recreational Value | $1,516,584 |

Source: Appendix K

#### *3.14.1.11 Dorena*

Dorena Dam is located on the Row River, a tributary of the Willamette River. Recreation sites around Dorena Reservoir are accessible via local roads off of Pacific Highway (Interstate 5). Dorena provides more than 2,400 acres of habitat for a variety of wildlife and plants and is a designated stop along the Big River Loop of the Willamette Valley Birding Trail. Visitors can see rare birds such as the purple martin, the willow flycatcher, and the yellow-breasted chat. Osprey and purple martins nest around the reservoir (USACE No Date-g). Anglers at Dorena Reservoir can catch rainbow trout (which are regularly stocked), largemouth bass, smallmouth bass, yellow perch, crappie, and bluegill (ODFW 2021b).

The managing agency, the months available, and many of the activities and amenities available at each recreation area are included below in Table 3.14-28. The recreation sites are shown below in Figure 3.14-8. USACE operates a campground (Schwarz Campground) located immediately downstream of the dam and two day-use parks (Harms Park and Bake Stewart Park). Schwarz Campground has fishing, boating, swimming, and hiking. The campground has 59 single campsites for RVs, trailers, and tents and six group campsites (Oregon's Best Camping 2021). Harms Park has a boat launch and visitors can hike along the adjacent Row River Trail. BLM operates the paved Row River Trail, which follows Dorena Reservoir’s north shore for over 5 miles with biking, hiking, and horseback riding.

Lane County operates Baker Bay Park which includes a day-use area, boat ramp, marina, campground with group camping and RV camping, dock/pier, hiking, multiuse play fields, a picnic area, children’s play equipment, swimming areas, and showers (Lane County No Date).

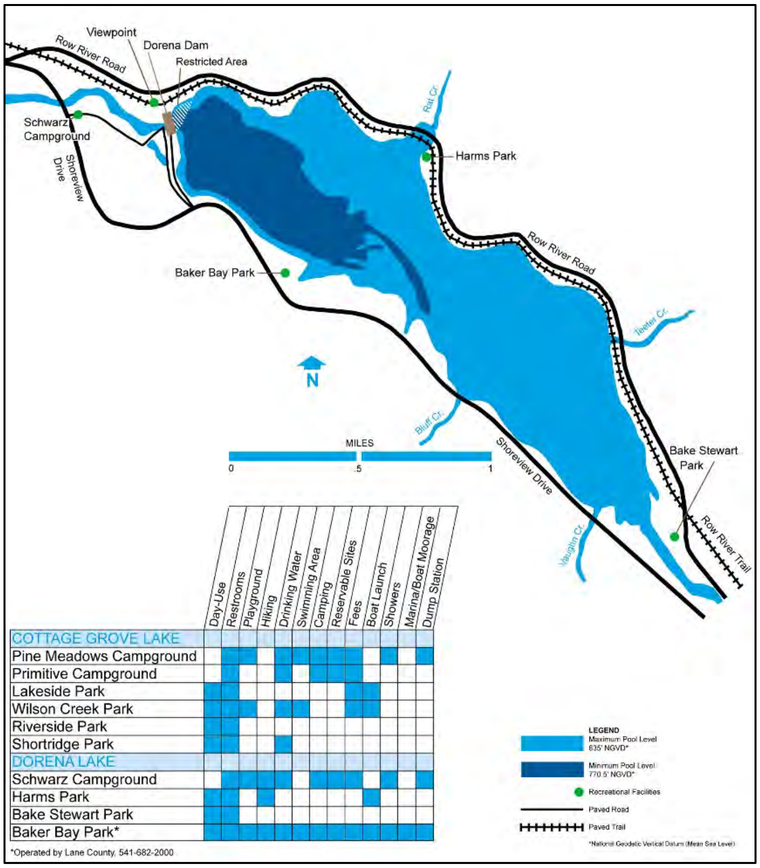


**Figure 3.14-8. Map of Recreation Sites at Dorena**

Source: USACE No Date-g

The activities and amenities available at each of these recreation sites are summarized below in Table 3.14-28.

**Table 3.14-28. Recreation Areas, Activities, and Amenities at Dorena Dam and Reservoir**

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Schwarz Campground | USACE | April - Sept | | ✓ | ✓ | ✓ | ✓ | | ✓ | | ✓ | ✓ | | ✓ | | ✓ |
| Harms Park | USACE | All Year | ✓ | ✓ | | ✓ | | | | | | | ✓ | | | |
| Bake Stewart Park | USACE | All Year | ✓ | ✓ | | ✓ | | | | | | | | | | |

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Baker Bay Park | Lane County | April - Oct | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Row River Trail | BLM | All Year | ✓ | ✓ | | ✓ | | | | | | | | | | |

BLM = Bureau of Land Management; USACE = U.S. Army Corps of Engineers

Source: USACE 2019h; USACE 2009d

In 2021, visitors to Dorena Reservoir participated most in angling, picnicking, and boating. Visitation for specific recreation activities at Dorena Reservoir is summarized below in Table 3.14-29.

**Table 3.14-29. Visits to Dorena Reservoir, FY 2021**

| Activity | 2021 Estimated Visits[1] |
|---|---|
| Picnickers | 36,065 |
| Campers | 12,186 |
| Swimmers | 25,000 |
| Water Skiers | 24,527 |
| Boaters | 29,653 |
| Sightseers | 18,047 |
| Anglers | 49,087 |
| Hunters | 7,009 |
| Total | 201,573 |

Source: USACE 2016j; USCB 2016; USCB 2021

[1] Estimated adjusted visits are indexed from 2016 to 2021 using data from U.S. Census Bureau 1-Year American Community Survey County level data.

* Note that numbers may not add up exactly due to rounding.

At Dorena Reservoir in 2021, 201,573 annual visits resulted in approximately $1,769,567 of recreational value as shown in below in Table 3.14-30.

**Table 3.14-30. Recreational Value of Dorena Reservoir, FY 2021**

| Description | U.S. Dollars |
|---|---|
| Total Annual Recreational Value | $1,769,567 |

Source: Appendix K

#### *3.14.1.12 Cottage Grove*

Cottage Grove Dam and Reservoir is located at river mile 29 of the Coast Fork of the Willamette River. Recreation sites around Cottage Grove Reservoir are accessible via local roads off of Pacific Highway (Interstate 5). Cottage Grove is a designated stop along the Big River Loop of the Willamette Valley Birding Trail where visitors can see rare birds such as the purple martin, the willow flycatcher, and the yellow-breasted chat. Similar to Dorena, osprey and purple martins nest along the reservoir (USACE No Date-c). Cottage Grove Reservoir is typically stocked with one-pound rainbow trout; anglers can also catch spotted bass, largemouth bass, crappie, yellow perch, and bluegill (ODFW 2021b).

The managing agency, the months available, and many of the activities and amenities available at each recreation area are included below in Table 3.14-31. The recreation sites are shown below in Figure 3.14-9. USACE operates two campgrounds (Pine Meadows Developed and Primitive campgrounds) and four day-use parks (Lakeside Park, Wilson Creek Park, Riverside Park, and Shortridge Park). Pine Meadows Developed Campground has 85 campsites, paved roads, showers, campfire rings, picnic tables, children's play area, and a marked, but unsupervised swim area with a life jacket loaner station. The primitive campground has 15 individual campsites, drinking water, gravel roads, picnic tables, and fire rings. Neither the developed nor the primitive campgrounds have hookups. Lakeside Park is located on London Road just past the dam and has paved roads and parking lots, picnic tables, fire rings, and a boat launch ramp with a courtesy dock and a life jacket loaner station. Wilson Creek Park has paved roads and parking lots, picnic tables, fire rings, a children's play area, an unsupervised swim area with a life jacket loaner station, and a boat launch ramp with a courtesy dock. Riverside Park is located on the east bank of the river (downstream from the dam) and is a minimally developed area with a gravel road and parking area, two picnic tables, and a paved path with pull-outs suitable for wheelchairs that is close enough to the river for fishing (USACE No Date-c).

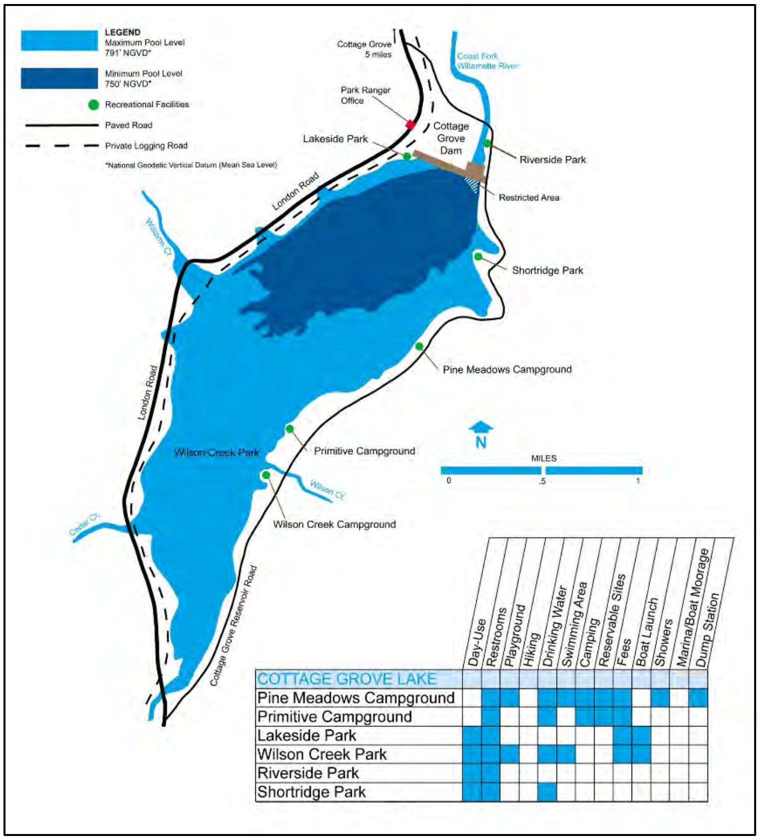


**Figure 3.14-9. Map of Recreation Sites at Cottage Grove**

Source: USACE No Date-c

The activities and amenities available at each of these recreation sites are summarized below in Table 3.14-31.

**Table 3.14-31. Recreation Areas, Activities, and Amenities at Cottage Grove Dam and Reservoir**

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pine Meadows Developed Campground | USACE | May - Sept | | ✓ | ✓ | | ✓ | ✓ | ✓ | | ✓ | ✓ | | ✓ | | ✓ |
| Pine Meadows Primitive Campground | USACE | May - Sept | | ✓ | | | ✓ | | ✓ | | ✓ | ✓ | | | | |

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lakeside Park | USACE | All Year | ✓ | ✓ | | | | | | | | | ✓ | | | |
| Wilson Creek Park | USACE | May - Sept | ✓ | ✓ | ✓ | | ✓ | ✓ | | | | | ✓ | | | |
| Riverside Park | USACE | May - Sept | ✓ | ✓ | | | | | | | | | | | | |
| Shortridge Park | USACE | May - Sept | ✓ | ✓ | | | | | | | | | | | | |

USACE = U.S. Army Corps of Engineers

Source: USACE 2019h; USACE 2009d

In 2021, visitors to Cottage Grove Reservoir participated most in boating, water skiing, and picnicking. Visitation for specific recreation activities at Cottage Grove Reservoir is summarized below in Table 3.14-32.

**Table 3.14-32. Visits to Cottage Grove Reservoir, FY 2021**

| Activity | 2021 Estimated Visits[1] |
|---|---|
| Picnickers | 59,238 |
| Campers | 3,446 |
| Swimmers | 51,839 |
| Water Skiers | 57,586 |
| Boaters[2] | 70,908 |
| Sightseers | 28,011 |
| Anglers | 44,601 |
| Hunters | 9,452 |
| Total | 325,083 |

Source: USACE 2016f; USCB 2016; USCB 2021

[1] Estimated adjusted visits are indexed from 2016 to 2021 using data from U.S. Census Bureau 1-Year American Community Survey County level data.

[2] Number of boaters are estimated for 2021 using regression analysis as described in Section 1.1 of Technical Appendix K -Recreation.

* Note that numbers may not add up exactly due to rounding.

At Cottage Grove Reservoir in 2021, 325,083 annual visits resulted in approximately $2,854,006 of recreational value as shown in below in Table 3.14-33. Cottage Grove is estimated to have the third most annual visits and third largest recreational value of USACE reservoirs in the WVS.

**Table 3.14-33. Recreational Value of Cottage Grove Reservoir, FY 2021**

| Description | U.S. Dollars |
|---|---|
| Total Annual Recreational Value | $2,854,006 |

Source: Appendix K

### *3.14.1.13 Fern Ridge*

Fern Ridge Dam and Reservoir is located at river mile 23.6 on the Long Tom River tributary of the Willamette River, about 12 miles west of Eugene, Oregon. Recreation sites around Fern Ridge Reservoir are accessible via local roads off of Florence-Eugene Highway, Territorial Highway, and Oregon Routes 99 and 569. Fern Ridge is a popular destination for fishing, boating, water skiing, swimming, camping, picnicking, hunting, and birding (USACE No Date-i). The large surface area and consistent winds make Fern Ridge one of the best sailing reservoirs in Oregon (USACE 2019a). The thousands of acres of emergent marsh (shallow-water wetlands) support summer breeding habitat for a variety of water-bird species, including Oregon's largest breeding colony of purple martins. USACE works with ODFW to support resident game and non-game fisheries within the Long Tom River Basin (USACE No Date-i). Anglers at Fern Ridge Reservoir can catch largemouth bass, crappie, bluegill, and brown bullhead. Bass and crappie are available throughout the spring and summer (ODFW 2021b). See the Fish, Aquatic Invertebrates, and Habitat Section for more information on how fisheries at Fern Ridge Reservoir are maintained.

The managing agency, the months available, and many of the activities and amenities available at each recreation area are included below in Table 3.14-34. The recreation sites are shown below in Figure 3.14-10. ODFW operates Fern Ridge Wildlife Area and East Kirk Park. The Fern Ridge Wildlife Area covers approximately half of the reservoir and consists of wetlands, wet prairie, oak and mixed woodlands, upland prairie, and freshwater aquatic habitats. It is a popular destination for water-based recreation, hunting, bird watching, hiking, and environmental education. Kirk Park is one of 11 management units within the Fern Ridge Wildlife Area; the eastern two-thirds of the area is designated for wildlife management and consists of woodland, meadow, marsh, and pond habitat. The western third of Kirk Park (West Kirk Park) is managed by USACE (ODFW 2020b).

USACE operates three day-use parks (West Kirk Park, Jeans Park, and Shore Lane Park). West Kirk Park is located below the dam off Clear Lake Road, and provides access to the Long Tom River and ponds and has trails, picnic tables, paved roads, and fire rings. Jeans Park is a wooded park with trails. It is located on Jeans Road on the west side of Fern Ridge Reservoir, and it includes visitor parking. Shore Lane Park is a small and rustic park that is often used for launching paddle craft.

Lane County operates four day-use sites: Richardson Park, Orchard Point Park, Perkins Peninsula Park, and Zumwalt Park. Richardson Park has a boat ramp, campground with group camping, RV camping, concessions, a dock/pier, hiking, a marina, a picnic area with shelter, children's play equipment, swimming areas, and showers. Orchard Point Park has a boat ramp, concessions, a dock/pier, a marina, multiuse play fields, a picnic area, children's play equipment, swimming areas, hiking, and a viewpoint. Perkins Peninsula Park has a boat ramp, a dock/pier, multiuse play field, a picnic area, swimming areas, hiking, and a viewpoint. Zumwalt Park has an interpretive trail, multiuse play fields, a picnic area, swimming areas, hiking, and a wildlife/natural area (Lane County No Date).

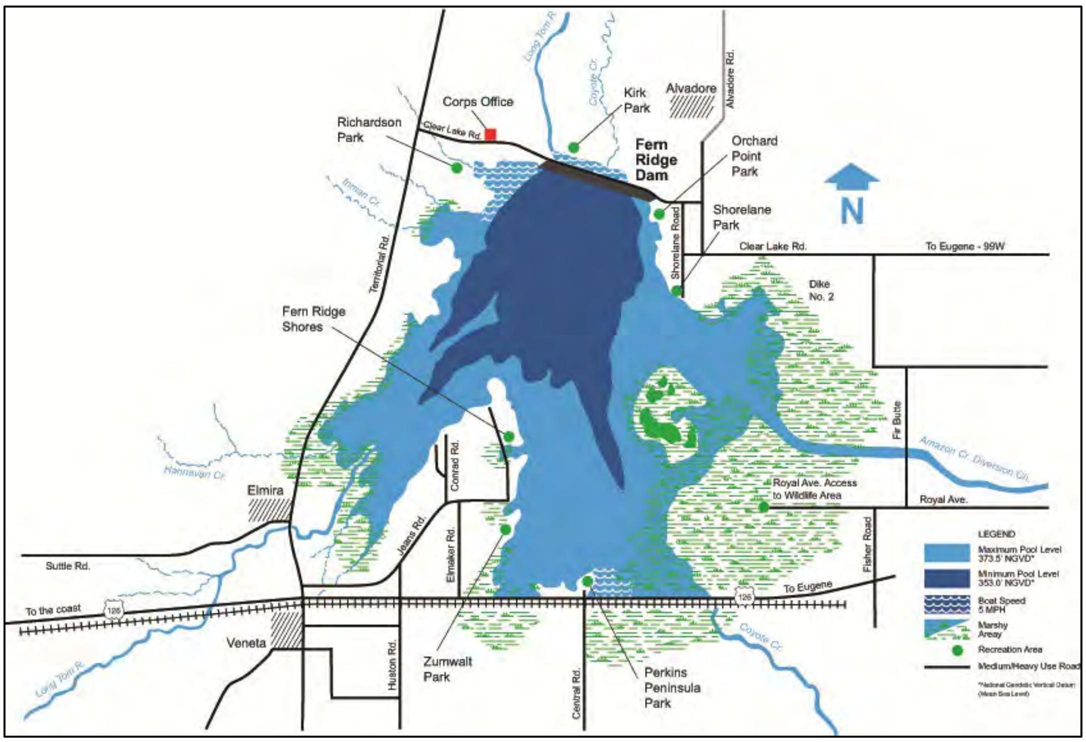


**Figure 3.14-10. Map of Recreation Sites at Fern Ridge**

Source: USACE No Date-i

The activities and amenities available at each of these recreation sites are summarized below in Table 3.14-34.

**Table 3.14-34. Recreation Areas, Activities, and Amenities at Fern Ridge Dam and Reservoir**

| Recreation Area | Managing Agency | Open | Day-Use | Restrooms | Playground | Hiking Trail | Drinking Water | Swimming Area | Camping/Camp Sites | RV Camp/Utilities | Reservable Sites | Fees | Boat Launch | Showers | Marina/Boat Moorage | Dump Station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| East Kirk Park | ODFW | All Year | ✓ | ✓ | | ✓ | | | | | | ✓ | | | | |
| West Kirk Park | USACE | May - Sept | ✓ | ✓ | | ✓ | | | | | | | | | | |
| Richardson Park | Lane County | April - Oct | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Orchard Pt. Park | Lane County | April - Oct | ✓ | ✓ | ✓ | | ✓ | ✓ | | | ✓ | ✓ | ✓ | | ✓ | |
| Perkins Peninsula Park | Lane County | April - Oct | ✓ | ✓ | | | ✓ | ✓ | | | | ✓ | ✓ | | | |
| Zumwalt Park | Lane County | All Year | ✓ | ✓ | | | | | | | | | | | | |
| Jeans Park | USACE | All Year | ✓ | ✓ | | ✓ | | | | | | | | | | |
| Shore Lane Park | USACE | May - Sept | ✓ | ✓ | | | | | | | | | | | | |
| Fern Ridge Wildlife Area | ODFW | All Year | ✓ | ✓ | | ✓ | | | | | | ✓ | | | | |

ODFW = Oregon Department of Fish and Wildlife; USACE = U.S. Army Corps of Engineers

Source: USACE 2019h; USACE 2009f

In 2021, visitors to Fern Ridge Reservoir participated most in picnicking, boating, and angling. Visitation for specific recreation activities at Fern Ridge Reservoir is summarized below in Table 3.14-35.

**Table 3.14-35. Visits to Fern Ridge Reservoir, FY 2021**

| Activity | 2021 Estimated Visits[1] |
|---|---|
| Picnickers | 184,125 |
| Campers | 15,138 |
| Swimmers | 109,010 |
| Water Skiers | 92,004 |
| Boaters | 180,016 |
| Sightseers | 84,704 |

| Activity | 2021 Estimated Visits[1] |
|---|---|
| Anglers | 123,267 |
| Hunters | 26,115 |
| Total | 814,378 |

[1] Source: USACE 2016l; USCB 2016; USCB 2021

[2] Estimated adjusted visits are indexed from 2016 to 2021 using data from U.S. Census Bureau 1-Year American Community Survey County level data.

* Note that numbers may not add up exactly due to rounding.

At Fern Ridge Reservoir in 2021, 814,378 annual visits resulted in approximately $6,006,087 of recreational value as shown in below in Table 3.14-36. Fern Ridge is estimated to have the most annual visits and largest recreational value of all USACE reservoirs in the WVS.

**Table 3.14-36. Recreational Value of Fern Ridge Reservoir, FY 2021**

| Description | U.S. Dollars |
|---|---|
| Total Annual Recreational Value | $6,006,087 |

Source: Appendix K

### *3.14.1.14 Riverine Recreation*

Similar to recreational opportunities in the vicinity of the dams and reservoirs, riverine recreation includes water-based recreation such as boating, kayaking, fishing, and swimming and land-based activities such as hiking, camping, and picnicking. Though the WVS does not release or regulate water specifically for downstream recreation, the timing and quantity of flows released from the 13 dams and reservoirs can affect downstream recreation opportunities including along the Long Tom River (from Fern Ridge Dam to Willamette River), the Mainstem Willamette River, McKenzie River, and North and South Santiam Rivers. The location of boat ramps along river segments can be used to illustrate which river segments are used for boat-related recreational activities. Figure 3.14-11 shows the location of boat ramps and boat access points throughout the WRB, with the greatest concentration of boat ramps occurring along the McKenzie River and North and South Santiam Rivers (USACE 2019a).


**Figure 3.14-11. Boating Access in the Willamette River Valley**

Source: USACE 2019a

### 3.14.2 Environmental Effects

This section discusses the potential effects of the Proposed Action and alternatives on recreation. The discussion includes the methodology, the measures within the action alternatives that were analyzed, a summary of the effects, and a detailed analysis for each alternative.

### *3.14.2.1 Methodology*

Potential effects to recreation were evaluated both quantitatively and qualitatively for reservoir and riverine areas.

1. Quantitative Analysis – Uses HEC-ResSim model[48] outputs and USACE Visitor Estimation & Reporting System (VERS) data to quantify changes in visitation and the associated economic benefit based on the reservoir water surface elevations (WSEs) in relation to boat ramp elevations. This portion of the analysis for reservoirs focuses on visitation and economic benefits. For riverine recreation, HEC-ResSim river flow outputs at river gage locations for the action alternatives were compared to the NAA to quantify effects.

2. Qualitative Analysis – Considers how changes to noise levels, air quality, visual resources, and traffic from construction; and changes to water levels from recurring deep drawdowns would affect the quality of the recreational experience at reservoirs and rivers, as applicable. This portion of the analysis focuses on the recreational experience.

#### *3.14.2.1.1 Quantitative Analysis*

The purpose of the quantitative analysis is to estimate average annual visitation at reservoirs and the associated economic benefits; and how the action alternatives would affect visitation and economic benefits compared to the NAA.

First, to estimate the average annual number of usable days, WSE data from the HEC-ResSim model was compared to boat ramp elevations at each reservoir during the peak recreation season (from May 15 to September 15). WSE data from the HEC-ResSim model was available for 83 full water years. The number of days in each season that the bottom of a given boat ramp elevation was lower than the WSE were counted as usable days, with the remaining days counted as unusable. (The top of a boat ramp should sit above the WSE and the bottom of the ramp should be deep enough for the boat to be backed into the water). Then, reservoir recreational visitor data from the USACE VERS was used to quantify how many people would visit each reservoir annually. A simplifying assumption was made that all people would visit the reservoirs during the peak recreation season from May 15 to September 15, i.e., visitation data was not separated by month or season: all annual visitation was grouped into the peak recreational season. Lastly, USACE Unit-Day-Value data was used to estimate the dollar value of a visit to a reservoir.

Because drawdowns would have a far more substantial effect on WSE compared to some of the other measures (e.g., use spillway for surface spill in summer), and boat ramp availability (which is tied to WSE) was used as the main factor in estimating visitation (as explained above),

[48] The HEC-ResSim model is described in detail in Appendix B, *Hydrology and Hydraulics.*

for each alternative, it is assumed that changes in visitation and riverine flows under each action alternative would occur as a result of deep drawdowns in the fall and spring. Therefore, to calculate changes in visitation and economic benefits for each action alternative, it is assumed that 90% of boaters and fishermen, 100% of water skiers, and 25% of swimmers, campers, sightseers, and picnickers would forego visiting the reservoir if the WSE is below the bottom of the boat ramps and the boat ramps are not usable. Applying these assumptions, the number of people that would visit each reservoir annually were calculated using the above-mentioned recreational visitor data from the USACE VERS. As done under the NAA, USACE Unit-Day-Value data from Economic Guidance Memorandum (EGM-21-02) was used to estimate the dollar value of recreational visits under each action alternative.

Visitation estimates are not made for riverine areas because of the many access points available to recreators, which are not operated by USACE. Therefore, riverine visitation data is not available. Instead, changes in flows for each alternative compared to the NAA are used as an indicator of general effects to riverine recreation. Modeling results indicate that changes in alternative flows could remain essentially unaffected at some reservoirs or rivers; or change up to 55 percent. The full results of visitation estimates are presented in Appendix K — Recreation Technical Report.

###### *3.14.2.1.2 Qualitative Analysis*

It is assumed that during a drawdown, some recreationists would not forego visiting a reservoir even if the WSE is below the bottom of the boat ramp and it is unusable. This is because boat ramps are only required to launch motorized boats. Non-motorized watercraft such as kayaks and paddleboards do not require boat ramps to launch. Additionally, fishing and swimming can be accessed from the shore, and land-based recreation like camping is generally available from mid-May to mid-September regardless of WSE. The *availability* of land-based recreation including but not limited to wildlife viewing (including birding), hiking, cycling, and picnicking are typically unaffected by changes in WSE; however, the *quality* of both land- and water-based recreational experiences would be affected by changes in WSE (e.g., recurring fall and spring drawdowns) regardless of an individual recreationist's location at the reservoir.

Independent of WSE, construction activities would also affect the quality of land- and water-based recreational experiences from increases in noise levels, air emissions, and traffic; as well as visual intrusions. Changes in the quality of recreation would increase proportionally with the proximity of the recreational facility to construction. At each dam and reservoir, effects at recreational facilities were analyzed spatially: facilities adjacent to construction would experience more severe effects, and those over two miles away would experience less adverse effects.

The quality of riverine recreation would also be affected from construction measures, regardless of the presence of USACE-managed recreational facilities. Similar to the quality of recreation at a facility on a reservoir, changes would increase proportionally with the proximity of the recreationist to construction. Riverine recreationists adjacent to construction would experience more severe adverse effects; and those further away would experience less severe adverse effects. Measures affecting recreational fishing in both reservoirs and rivers, whether directly or indirectly, were also considered. The quality of recreational fishing in reservoirs and on rivers for some species could be adversely impacted due to increased turbidity from suspended sediment associated with construction measures and drawdowns. In the long-term, many (most) measures aim to improve fish habitat and increase fish populations and therefore would benefit recreational fishing.

*3.14.2.1.3 Evaluation Criteria*

The magnitude of effects is determined using both the quantitative and qualitative portions of the analysis described above, as appropriate. Most of the proposed measures (e.g., maintain revetments using nature-based methods, install gravel below dams) would not directly affect visitation; in these cases, the effects are qualified. Reservoir drawdowns would drastically change the WSE and would both directly affect visitation and the recreational experience; these effects are described both quantitatively and qualitatively. Table 3.14-37 describes the evaluation criteria for the effect factors (magnitude, duration, and extent), and provides a definition for the scale of each effect factor.

**All comparisons of effects for each action alternative are in comparison to the NAA unless stated otherwise.**

**Table 3.14-37. Evaluation Criteria for Potential Effects to Recreation**

| Effect Factors and Scale | Definition |
|---|---|
| **Magnitude** | |
| Negligible | Changes in visitation and economic benefits at reservoirs are not measurable or change less than one percent compared to baseline conditions. Changes in flows at select gage locations in riverine areas are not measurable or change less than one percent compared to baseline conditions. Impacts from changes in noise, air quality, visual resources, traffic, or other conditions would not affect the quality of recreational experiences. |
| Minor | Changes in visitation and economic benefits at reservoirs or flows at select gage locations in riverine areas are between one and five percent compared to baseline conditions. Impacts from changes in noise, air quality, visual resources, traffic, or other conditions would be slightly noticeable and begin to affect the quality of recreational experiences. |
| Moderate | Changes in visitation and economic benefits at reservoirs or flows at select gage locations in riverine areas are between five and twenty percent compared to baseline conditions. Impacts from changes in noise, air quality, visual resources, traffic, or |

| Effect Factors and Scale | Definition |
|---|---|
| | other conditions would be noticeable and affect the quality of recreational experiences. |
| Major | Changes in visitation and economic benefits at reservoirs or flows at select gage locations in riverine areas are more than twenty percent compared to baseline conditions. Impacts from changes in noise, air quality, visual resources, traffic, or other conditions would be very noticeable and significantly affect the quality of recreational experiences. |
| **Duration** | |
| Short-term | Alteration lasts for the duration of small construction project, and is continuous for less than 2 years. |
| Medium-term | Alteration is limited to the duration of large construction projects, and is continuous for a period of 2-5 years. |
| Long-term | Alteration is permanent or lasts continuously beyond operation changes or the completion of all construction projects; the alteration recurs at regular intervals (e.g., deep drawdowns that occur for a 3-week period in the fall and/or spring); or the alteration occurs intermittently. |
| **Extent** | |
| Local | Changes to visitation, economic benefits, or the recreational experience would be confined to the dam/reservoir or river. |
| Regional | Changes to visitation, economic benefits, or the recreational experience would be perceived throughout a single county, multiple counties, or the entire WVS. |
| State-wide | Changes to visitation, economic benefits, or the recreational experience would be perceived throughout the entire state. |

#### *3.14.2.2 Measures Analyzed for Recreation*

All measures under the action alternatives could impact recreation, either directly or indirectly. These measures are:

- Construct water temperature control (WTC) tower (#105)
- Use regulating outlets (ROs) to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166)
- Structural improvements to reduce total dissolved gas (TDG) (#174)
- Integrated temperature and habitat flow regime (#30a)
- Refined Integrated temperature and habitat flow regime (#30b)
- Augment instream flows by using the power pool (#304)

- Gravel augmentation below dams (#384)
- Construct structural downstream fish passage (#392)
- Deeper fall reservoir drawdowns for fish passage (#40)
- Foster Fish Ladder Temperature Improvement (#479)
- Provide Pacific lamprey passage and infrastructure (#52)
- Restore upstream and downstream passage at drop structures (#639)
- Pass water over spillway in spring for fish passage (#714)
- Augment instream flows by using the inactive pool (#718)
- Adapt Hatchery Program (#719)
- Spring reservoir drawdown for downstream fish passage (#720)
- Use spillway for surface spill in summer (#721)
- Construct adult fish facility (AFF) (#722)
- Reduce minimum flows to Congressionally authorized minimum flow requirements (#723)
- Maintenance of existing and new fish release sites above dams (#726)
- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)
- Fall Creek drawdown
- Continued Operation of Existing Adult Fish Facilities
- Operation, Maintenance, Repair, Replacement and Rehabilitation

A summary of the recreation effects discussed in the sections below is provided in Table 3.14-38. Note that where a range of potential effects would occur, the most severe magnitude of adverse effects and the lesser magnitude of beneficial effects for each alternative was listed in this table. For example, if there is a range of minor to moderate adverse effects, moderate adverse effects are included in the table. If beneficial effects would range from minor to moderate, the table includes minor beneficial effects. Said otherwise, the most conservative conclusions of potential effects are presented in the table below in order to avoid overstating potential beneficial effects and understating adverse effects. Also, the extent of effects includes all reservoirs where potential effects would occur, even if the most severe adverse effect or the lesser beneficial effect does not occur at that reservoir. This follows the approach to present the most conservative conclusions in this table; instead of simply omitting reservoirs where less severe or more beneficial effects would occur. Discussion of all adverse and beneficial effects are included below.

**Table 3.14-38. Summary of Effects to Recreation Under Each Alternative**

| Effect Factor | Alternative | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NAA | 1 | 2A | 2B | 3A | 3B | 4 | 5 |
| | **Short-Term** | | | | | | | |
| Magnitude | Major adverse | Major adverse | Major adverse | Major adverse | Major adverse | Major adverse | Major adverse | Major adverse |
| Extent | Local (basin-wide, FCR) | Local (basin-wide; FRN, GPR, BCL, BLU, CGR, FOS, FCR) | Local (basin-wide BCL, BLU, CGR, FOS, GPR, FCR) | Local (basin-wide, BCL, BLU, CGR, FOS, GPR, FCR) | Local (basin-wide, BCL, BLU, CGR, FOS, GPR, HCR, FCR) | Local (basin-wide, BCL, BLU, CGR, FOS, GPR, HCR, FCR) | Local (basin-wide, BCL, BLU, CGR, FOS, FRN, HCR, FCR) | Local (basin-wide, BCL, BLU, CGR, FOS, GPR, FCR) |
| | **Medium-Term** | | | | | | | |
| Magnitude | Moderate adverse | Moderate adverse | Moderate adverse | Moderate adverse | Moderate adverse | Moderate adverse | Moderate adverse | Moderate adverse |
| Extent | Local (basin-wide) | Local (basin-wide, DET, LOP, CGR, FOS, GPR) | Local (basin-wide, DET, CGR, DET, LOP, FOS, GPR) | Local (basin-wide, DET, LOP, FOS, GPR, CGR) | Local (basin-wide, BLU, GPR, HCR, FOS) | Local (basin-wide, FOS, BLU, GPR, HCR, CGR) | Local (basin-wide, CGR, DEX, FOS, GPR, DET, HCR, LOP, FOS) | Local (basin-wide, DET, LOP, FOS, GPR, CGR) |
| | **Long-Term (Permanent, Intermittent, and/or Recurring)** | | | | | | | |
| Magnitude | Major adverse | Moderate beneficial; major adverse | Major adverse | Major adverse | Major adverse | Major adverse | Major adverse | Major adverse |
| Extent | Local (basin-wide, FCR) | Local (basin-wide, FCR) | Local (basin-wide, GPR, FCR, CGR, GPR, LOP) | Local (basin-wide, CGR, GPR, FCR, LOP, FOS) | Local (basin-wide, CGR, GPR, LOP, FOS, HCR, DET, BLU, FCR) | Local (basin-wide, CGR, GPR, LOP, HCR, FOS, DET, BLU, FCR) | Local (basin-wide, CGR, GPR, LOP, FOS, FCR) | Local (basin-wide, CGR, GPR, FCR, LOP, FOS) |
| Duration Type | Recurring | Permanent; Recurring | Permanent; Recurring | Permanent; Recurring | Permanent; Recurring | Permanent; Recurring | Permanent; Recurring | Permanent; Recurring |

In the following subsections, the effects are discussed for the No Action Alternative and the measures analyzed in the action alternatives.

#### *3.14.2.3 Discussion of Effects by Measure(s)*

This section applies the methodology described above to each measure analyzed for the resource to determine the potential effects. Where possible, the discussion of the magnitude and duration of effects is grouped by measures that would have similar effects. The effects by measure or measures will then be referenced in the action alternative's analysis that follows. The extent of effects is discussed by dam/reservoir under the appropriate alternative. The following would require construction, as described above in Section 3.1.4.2

- Gravel augmentation below dams (#384)
- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)
- Maintenance of existing and new fish release sites above dams (#726)
- Operation, maintenance, repair, replacement and rehabilitation
- Foster fish ladder temperature improvement (#479)
- Construct WTC tower (#105)
- Use spillway for surface spill in summer (#721)
- Structural improvements to reduce total dissolved gas (#174)
- Restore upstream and downstream passage at drop structures (#639)
- Construct AFF (#722)
- Provide Pacific lamprey passage and infrastructure (#52)
- Construct structural downstream fish passage (#392)
- Deeper fall reservoir drawdowns for fish passage (#40)

This section will discuss general, qualitative effects on recreation from construction at the programmatic level. Site-specific project details for each construction measure will be determined during the implementation phase. Subsequent tiered NEPA documents would discuss detailed site-specific effects.

#### *3.14.2.3.1 Gravel augmentation below dams (#384), Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), Maintenance of existing and new fish release sites above dams (#726), Restore upstream and downstream passage at drop structures (#639), and Use spillway for surface spill in summer (#721)*

The magnitude of effects from augmenting gravel below dams; maintaining or altering revetments; maintaining existing and new fish release sites above dams; and restoring upstream and downstream passage at drop structures would be adverse and negligible to minor in magnitude in the short term, and beneficial, indirect, and minor in magnitude in the long term. At Blue River and Hills Creek only, effects from using the surface spillway for surface spill in the summer would be adverse and negligible to moderate in magnitude in the short term, but would have the same beneficial effects.

Potential effects from these measures are determined below. The effects analyses for augmenting gravel below dams, maintaining or altering revetments for ecosystem restoration, and maintaining existing and new fish release sites above dams is referred back to under all action alternatives; the effects of restoring upstream and downstream passage at drop structures is referred back to under Alternatives 1 and 4; and the effects of using the surface spillway for surface spill in the summer is referred back to under Alternatives 2A, 2B, 3A, 3B, 4, and 5.

Augmenting gravel below dams would add clean round river gravel to areas of wetted streambeds of rivers below dams that have ESA-listed UWR Chinook salmon and UWR steelhead. Augmenting gravel is likely to occur downstream of dams in relatively close proximity to dams themselves because these areas can experience river-substrate issues due to the water flowing out of dam outlets. Maintaining or altering revetments for aquatic ecosystem restoration would decrease hard surfaces (e.g., rock) within the WVS and could occur at any of the 43 miles of USACE-maintained revetment locations (including the mainstem Willamette River) as described in Section 2.4.2.3. Maintaining existing and new fish release sites above dams may require minor grading and tree removal at the proposed Blue River, Cougar, Detroit, Foster, Green Peter, and Lookout Point outplanting sites. The approach and design of restoring upstream and downstream passage at drop structures would be determined during the design phase, but could include the construction of fish ladders, direct modifications to drop structures, bypass channels, or the replacement of drop structures with riffle and pool systems. Kirk Park, the only recreational facility downstream of the Fern Ridge, is approximately six miles away from the nearest drop structure at Cox Butte where fish passage would be restored. Therefore, recreational facilities would be virtually unaffected by construction. However, these measures would occur in or on the rivers downstream of dams at varying levels of proximity to the dams, where there may or may not be an adjacent USACE-managed recreational facility. Any measures that involve construction on a river could affect the quality of the recreational experience for riverine recreators participating in boating, swimming, and fishing – regardless of the presence of USACE-managed recreational facilities.

These measures could all affect the recreational experience at or near construction-project locations with noise and air emissions, traffic from hauling material, and could generally attract attention from changes in visual resources. Additionally, the quality of recreational fishing along rivers for some species could be adversely impacted in the short-term due to the increased turbidity from suspended sediment caused by gravel augmentation or revetment alteration. The severity of short-term construction-related effects on the quality of recreation are considered qualitatively as follows. For areas that may not have a USACE recreational facility, such as at rivers downstream of dams, the severity of effects on the quality of the recreational experience are based on the proximity of a recreator to the construction project (i.e., not limited to a USACE recreational facility, such as a park). Effects would be minor to a recreator passing by the project location, and negligible as the distance from the construction project location increases. Similarly, for areas that do have a USACE recreational facility, effects on the quality of the recreational experience are based on the proximity of the recreational facility to the construction project. Effects would be minor at recreational facilities adjacent to the construction location, and be negligible for facilities more than one or two miles away from the construction.

In summary, changes in the quality of recreation would range from not noticeable to slightly noticeable and increase proportionally with the proximity of the recreator or recreational facility to construction, therefore, adverse effects would range from negligible to minor in magnitude. Changes in the quality of recreation would last the duration of the small construction projects, so effects would be short term.

These measures would not directly benefit recreation, but would improve fish habitat and passage over time, and could increase the population of native fish species available for recreational fishing in the long term. As such, benefits would be indirect because they would be caused by the action but would occur later in time or be farther removed in distance, but still be reasonably foreseeable. Thus, these measures would have indirect, beneficial, and minor effects to recreational fishing in the long term.

Using the surface spillway for surface spill in the summer would require spillway channel modifications at Blue River and Hills Creek only. At Blue River and Hills Creek there would be negligible to moderate in magnitude and short term in duration effects from construction, similar to the measures described above in this section. These effects would be moderate rather than minor because hydraulic excavators would be required to excavate and regrade the spillway, which would have more severe effects on recreation. At all locations, there would be indirect, beneficial, and minor effects to recreational fishing in the long term.

Therefore, potential adverse effects would be negligible to minor in magnitude (negligible to moderate at Blue River and Hills Creek from construction for using the surface spillway for summer spill) and short term in duration; and potential beneficial effects would be indirect, minor in magnitude, and long term in duration.

#### *3.14.2.3.2 Provide Pacific lamprey passage and infrastructure (#52)*

The magnitude of effects from providing pacific lamprey passage and infrastructure would be negligible to minor in the short term. Potential effects from construction of these structures are determined below and referred back to under all action alternatives.

Like the measures described above in Section 3.14.2.3.1, this measure could affect the recreational experience at or near construction-project locations with noise and air emissions, traffic from hauling material, and could generally attract attention from changes in visual resources. Pacific lamprey passage and infrastructure would be located next to the dams, all of which are immediately adjacent to at least one recreation area (primarily viewpoints and parks). Changes in the quality of recreation would range from not noticeable to noticeable, increasing proportionally with the recreational facility's proximity to the construction, therefore, adverse effects would range from negligible to minor in magnitude. Changes in the quality of recreation would last the duration of the small construction projects, so effects would be short term.

Pacific lamprey is only harvested for subsistence purposes in the WVS and cannot be fished recreationally. So, unlike other structural improvement projects, no long-term direct or indirect benefits to recreational fishing would occur as a result of providing pacific lamprey passage and infrastructure.

#### *3.14.2.3.3 Operation, Maintenance, Repair, Replacement and Rehabilitation*

The magnitude of effects from operation, maintenance, repair, replacement, and rehabilitation would be adverse and negligible to minor in magnitude in the short and long term for scheduled/routine maintenance, and be adverse and negligible to moderate in the medium and long term for major maintenance and rehabilitation. Potential effects from this measure are determined below and referred back to under each action alternative.

Similar to the measures described above in Sections 3.14.2.3.1 and 3.14.2.3.2, operation, maintenance, repair, replacement, and rehabilitation could affect the recreational experience at or near construction-project locations with noise and air emissions, traffic from hauling material, and could generally attract attention from changes in visual resources. These activities could be located next to the dams, all of which are immediately adjacent to at least one recreation area (primarily viewpoints and parks), but could also occur at any USACE-managed facility in the WVS that requires maintenance. Changes in the quality of recreation would increase proportionally with the recreationist or recreational facility's proximity to the operation, maintenance, repair, replacement, or rehabilitation activity.

For scheduled/routine maintenance, changes in the quality of recreation would range from not noticeable to noticeable, therefore, adverse effects would be negligible to minor in magnitude. Changes in the quality of recreation would last the duration of the small construction projects, so effects would be short term. Effects from major maintenance and rehabilitation projects would generally be greater in magnitude than scheduled/routine maintenance due to the potential use of heavy-duty construction equipment and the projects generally being more intensive. Changes in the quality of recreation would range from negligible to moderate in magnitude and last the duration of the large construction projects, so effects would be medium-term. Major maintenance and rehabilitation projects would undergo additional tiered NEPA analysis where specific actions would be analyzed and detailed effects would be described. Because both scheduled/routine maintenance and major maintenance and rehabilitation would occur throughout the life of the project, effects would also be long term.

*3.14.2.3.4 Integrated temperature and habitat flow regime (#30a), Refined integrated temperature and habitat flow regime (#30b), Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166), Augment instream flows by using the inactive pool (#718), Augment instream flows by using the power pool (#304), Pass water over spillway in spring for fish passage (#714), and Continued Operation of Existing AFFs*

The magnitude of indirect effects from these measures would be minor and beneficial in the long term. The integrated temperature and habitat flow regime is referred back to under Alternatives 2A, 2B, 3A, 3B, and 4, and the revised integrated temperature and habitat flow regime is referred back to under Alternative 5. Using regulating outlets to discharge cold water is referred back to under Alternatives 2A, 2B, 3A, 3B, 4, and 5. Using water from the inactive and power pools to increase downstream river flows and continuing operation of existing AFFs are referred back to under all action alternatives. Passing water over the spillway in spring for fish passage is referred back to under Alternatives 2A, 2B, 3A, 3B, and 5.

Flow measures would improve fish habitat, and existing AFFs are operated to protect and enhance anadromous and resident fish species. Similar to the measures discussed above in Section 3.14.2.3.1, these measures would not directly affect recreation, but would improve fish habitat and passage over time, and could increase the population of native fish species available for recreational fishing in the long term. Benefits to fish habitat would primarily be to water temperature, but flow measures could also improve riparian vegetation, which would help reduce bank erosion and provide additional benefits to fish habitat by way of increased spawning areas and improved aquatic insect habitat. The improvement of riparian vegetation would also generally improve aesthetics and subsequently benefit the recreational experience. Further, higher stream flows support higher recreational carrying capacity: the number of anglers that can use the same stretch of river at once could increase (Duffield, Neher, and Brown 1992).

As such, these measures would have indirect, beneficial, minor effects to recreation in the long term.

##### *3.14.2.3.5 Reduce minimum flows to Congressionally authorized minimum flow requirements (#723)*

The magnitude of effects from reducing minimum flows to Congressionally authorized minimum flow requirements would be moderate and beneficial at reservoirs and minor to moderate and adverse at rivers in the long term. These potential effects are determined below and referred back to under Alternative 1.

This measure would allow reservoirs to capture more spring runoff instead of releasing it to meet reservoir refill objectives. As a result of this measure, reservoirs would refill faster in the spring and reach their conservation season pool elevations earlier in the season. A full reservoir during the early parts of the season would improve the experience of both land- and water-based recreation, and it would also extend the recreational season. These beneficial effects would be noticeable, so they would be moderate in magnitude. While benefits would occur at reservoirs, there would be adverse effects to riverine recreation downstream of reservoirs. When dam outflows are reduced, reservoirs would fill faster, but river water levels would be lower. Lower river water levels could range from slightly noticeable to noticeable depending on the river, reach, and season, therefore effects would be minor to moderate in magnitude. Flows would change for the life of the project, making effects at both dams and rivers long term in duration. While exact visitation at rivers is unknown, visitation at reservoirs is higher than in rivers; therefore, the beneficial effects would be felt by more recreators at reservoirs than the adverse effects in rivers.

##### *3.14.2.3.6 Adapt Hatchery Program (#719)*

Adapting the hatchery program would have indirect, adverse, and negligible effects in the long term. Potential effects are determined below and referred back to under all action alternatives.

Hatchery production levels would be adjusted based on the efficacy of fish passage measures. USACE has mitigated the blocking of habitat of migratory fish by carrying out a program to produce and release hatchery UWR Chinook salmon, UWR steelhead, and trout in the WVS. Hatchery production levels would be decreased as the amount of accessible fish habitat resulting from fish passage measures increases. Similar to those discussed above in Section 3.14.2.3.1, this measure would not directly affect recreation, but would affect fish populations. Therefore, the effects would be indirect. Hatchery levels would not be decreased until improved fish passage is observed, so effects would be long term. Changes to recreation would not be noticeable, so adverse effects on recreational fishing would be negligible in magnitude.

##### *3.14.2.3.7 Structural improvements to reduce total dissolved gas (#174), Construct WTC towers (#105), Construct structural downstream fish passage (#392), Foster Fish Ladder Temperature Improvement (#479), and Construct AFFs (#722)*

The magnitude of effects from improving structures to reduce TDG, constructing WTC towers and downstream passage infrastructure, the Foster fish ladder temperature improvement, and constructing AFFs would be negligible to moderate and adverse in the medium term (negligible to minor and adverse in the short term at Foster from constructing downstream passage infrastructure), and indirect, beneficial, and minor in the long term.

Potential effects from improving TDG structures are determined below and referred back to under Alternatives 1 and 4. Effects from constructing WTC towers, structural downstream fish passage infrastructure, and the Foster fish ladder temperature improvement are referred back to under Alternatives 1, 2A, 2B, 4, and 5. Effects from constructing AFFs are referred back to under all action alternatives.

These measures could involve the use of heavy-duty construction vehicles such as trucks, dozers, backhoes, and/or cranes, and would generally be more intensive projects than those described above in Sections 3.14.2.3.1 and 3.14.2.3.2. Construction could disturb recreators with noise and air emissions, traffic from hauling material, and could generally attract attention from changes in visual resources. Construction would be located next to the dams, all of which are immediately adjacent to at least one recreation area (primarily viewpoints and parks). Changes in the quality of recreation would range from not noticeable to noticeable, and increase proportionally with the proximity of the recreational facility to construction; therefore, adverse effects would range from negligible to moderate in magnitude. Changes in the quality of recreation would last the duration of the large construction project, so effects would be medium term. At Detroit and Lookout Point (as well as at Green Peter, under Alternative 1 only), the WTC towers would be designed to reduce TDG (i.e., no separate TDG structures would be developed). At these locations, there would be no separate construction effects from structural improvements to reduce TDG because these effects would be included with those of constructing the WTC towers themselves. Note that, at Foster under measure #392, improvements to the 'surface route structure' fish weir would be made, which is a modification of one of the dam's spillways. This would be a simpler and shorter construction project than those required for the downstream passage FSSs or FSCs and similar to those described in Section 3.14.2.3.1. Therefore, the effects from constructing downstream passage infrastructure at Foster would be adverse and negligible to minor in magnitude in the short term.

As described above in Section 3.14.2.3.1, these measures would not directly benefit recreation, but would improve fish habitat and passage over time, and could increase the population of native fish species available for recreational fishing in the long term.

Therefore, potential adverse direct effects would be negligible to moderate in magnitude and medium term in duration, and potential beneficial effects would be indirect, minor in magnitude, and long term in duration.

##### *3.14.2.3.8 Deeper fall reservoir drawdowns for downstream fish passage (#40), Spring reservoir drawdown for downstream fish passage (#720), and Fall Creek drawdown*

The magnitude of effects from drawing down reservoirs in the fall and spring for fish passage and the Fall Creek drawdown would be major, adverse, short term, and recur in the long term and indirect, beneficial, and minor in the long term. Effects would be negligible to major in magnitude and medium term in duration at Cougar for the construction required to drawdown to the diversion tunnel (DT). Potential effects from deeper fall drawdowns are determined below and referred back to under Alternatives 2A, 2B, 3A, 3B, and 5. Effects from spring reservoir drawdowns are referred back to under Alternatives 2B, 3A, 3B, and 5. Effects from the Fall Creek drawdown are referred back to under all alternatives.

As described in Section 3.14.2.1, the effects of drawdowns on visitation at reservoirs were quantified but the effects on visitation for riverine areas were not quantified. Instead, changes in alternative flows compared to the NAA are used as an indicator of general effects to recreation. It is assumed that changes in visitation and flows under each action alternative would occur as a result of deep drawdowns in the fall and spring; therefore, results of the model by reservoir and river/river reach are included below in the discussion by alternative. The magnitude of effects would range from negligible to major. The timing (season) and release (volumetric flow rate) of river flows downstream of WVS reservoirs would especially affect certain types of water-based riverine recreation, such as white-water rafting and fishing via boat[49]. For the purposes of this analysis, increases in river flows are generally assumed to benefit riverine recreation because of increased water availability. However, depending on the river reach and other factors such as season, substantial increases in river flows could potentially be dangerous for water-based riverine recreationists due to dangerous currents and waterborne hazards such as logs and trees (Chalmers 2019). Riverine recreationists should always check river conditions[50] before recreating, and caution should always be exercised during all recreational activities.

As described in Section 3.14.2.2, drawdowns would also affect the recreational experience. It is assumed that some recreationists will continue to visit the reservoir despite drastic changes in the WSE. In general, spring drawdowns would have a more noticeable effect on WSE and subsequent recreational quality than fall drawdowns. This is because spring inflows are paramount in reservoirs reaching their conservation season elevation (in May, typically. See Section 3.2, Hydrologic Processes, for more information), and these inflows would have to be released in order to draw-down reservoirs. Additionally, spring drawdowns would occur before the peak recreation season begins in May, which could shorten the recreation season. Fall drawdowns would begin during the peak recreation season, which also has the potential to shorten the season, although not as long as with spring drawdowns. After fall drawdowns, reservoirs would still have their typical winter and spring inflows in order to refill to their conservation season elevation. But for any drawdown, changes would be very noticeable due to the visual impact of the drawdown, which would substantially impact the recreational experience for recreationists that continue to visit the reservoir during drawdowns.

Reductions in visitation at some reservoirs and in recreational quality at all reservoirs would cause adverse effects to be major overall. Because drawdowns would last for approximately

[49] Rivers are commonly fished via drift boat, a type of small, non-motorized row boat. Drift boats are especially popular in shallow river reaches that are inaccessible by traditional motorized boats.
[50] Real-time river flow data are available via the USGS National Water Dashboard at https://dashboard.waterdata.usgs.gov/app/nwd/?region=lower48&aoi=default

three weeks out of the year and recur for the life of the project, adverse effects would be long-term recurring in duration. Additionally, drawdowns would improve fish passage, which would have minor and indirect beneficial effects on recreation by enhancing fishing over time. The beneficial effects would be long term in duration.

Note that, at the Cougar Reservoir, drawdowns to the DT would require dam modifications, including the construction of a tower and bridge. The construction would be similar to that described above in Section 3.14.2.3.7: relatively intensive construction could disturb recreators with noise and air emissions, traffic from hauling material, and could generally attract attention from changes in visual resources. The construction would also require an extended deep drawdown so that concrete placement could occur in dry conditions. Potential adverse effects from the construction (i.e., concrete placement) that would require the fall drawdown to Cougar's DT would be negligible to major in magnitude and medium term in duration.

Therefore, potential adverse effects from construction would be negligible to moderate in magnitude and medium term in duration (for Cougar DT drawdowns only), and major in magnitude in the short term and long-term recurring in duration (for all drawdowns). Potential beneficial effects would be indirect, minor in magnitude, and long term in duration.

#### *3.14.2.3.9 Suite of near-term operations*

The suite of near-term operations includes 16 measures at various locations to provide relief for ESA-listed species until they can be replaced with the measures in the Preferred Alternative. The magnitude of effects from the suite of near-term operations would be moderate to major, adverse, and recur in the long term, and be indirect, beneficial, and minor in the long term. Potential effects from the suite of near-term operations are determined below and referred back to under Alternatives 2A, 2B, 3A, 3B, 4, and 5.

Several actions within the suite of near-term operations would have similar effects to recreation as the measures discussed above in Section 3.14.2.3.8. Deep drawdowns at Cougar, Green Peter, Lookout Point, and Fall Creek, and the delayed refills at Fall Creek and Cougar (which would lengthen the effects of the deep drawdowns), would result in very noticeable visual impacts and could shorten the recreational season. Drawdowns and drawdowns with delayed refills would have major adverse effects on the recreational experience. Additionally, refill would be delayed at Foster despite not including a drawdown. This could have noticeable visual impacts and shorten the recreation season, although not as drastically as the deep drawdowns. The adverse effects at Foster would be moderate.

The other actions in the suite of near-term operations, such as RO prioritization, the outplanting plan, and using spillways to improve TDG, temperature, and fish passage would have indirect benefits as discussed above in Section 3.14.2.3.1. These actions would not directly affect recreation, but would improve fish habitat and passage over time, and could increase the population of native fish species available for recreational fishing in the long term. Thus, these measures would have indirect, beneficial, and minor effects to recreational fishing in the long term.

#### *3.14.2.4 No Action Alternative*

Under the NAA, the existing O&M of the WVS would continue with no changes. As discussed under Section 3.14.2.1, the availability of water-based recreation and the quality of both water- and land-based recreation is dependent on WSE. Under the NAA, WSEs would not change from how they are currently maintained. Conservation pool elevations would continue to be maintained high until early September, at which point the reservoirs with lower recreation demand would be used first to meet summer flow requirements (measured at Albany and Salem). Water from the Detroit, Fern Ridge, and Foster reservoirs would continue to be used last because of their recreational importance.

The NAA includes water quality, flow, and upstream and downstream passage operations. Water quality operations include using the spillway to release warm surface water and manage downstream temperatures at Foster and Detroit; strategically using outlets to meet temperature targets (when possible) at Fall Creek; operating the Cougar WTC tower to manage downstream temperatures; spreading spill across the Dexter and Big Cliff spillways to reduce TDG; and discharging water through the powerhouse at power-producing dams to reduce TDG. Flow operations include meeting the 2008 BiOp targets basin-wide and augmenting flows using the inactive or power pool at Green Peter. Flow operations would primarily benefit fish habitat through water temperature, but could also improve riparian vegetation which would generally improve aesthetics and subsequently benefit the riverine recreational experience. Higher stream flows would also increase riverine recreational carrying capacities. Fish passage operations include passing fish over the Foster spillway and through the lowest RO at Fall Creek (Fall Creek drawdown). The recurring drawdown at Fall Creek would have major, adverse, short-term and long-term recurring effects like those discussed above in Section 3.14.2.3.8.

Operation, maintenance, repair, replacement, and rehabilitation would continue to adversely impact the recreational experience at recreation areas immediately adjacent the dams and effects would increase proportionally with the recreational facility’s proximity to these activities. As described above in Section 3.14.2.3.3, effects to the recreational experience would be would be adverse and negligible to minor in magnitude in the short and long term for scheduled/routine maintenance, and be adverse and negligible to moderate in the medium and long term for major maintenance and rehabilitation due to increases in noise, air emissions, visual intrusions, and traffic.

The NAA is the baseline for which visitation estimates are made; therefore, there would be no effects to average annual visits or average annual benefits (Appendix K– Recreation Technical Report). The extent of effects would be local because impacts to the quality of recreation would be confined to the dam/reservoir. Ongoing operation and routine and non-routine maintenance activities would occur in the short, medium, and long term.

##### *3.14.2.4.1 Climate Change*

As discussed in Appendices F1 and F2 (Qualitative Assessment of Climate Change Impacts and Supplemental Climate Change Information, respectively), climate change is expected to result in wetter winters (where more precipitation falls as rain rather than snow), less snowpack, drier summers, increased air and water temperatures, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB, independent of the O&M of the WVS over the next 30 years. These factors would exacerbate adverse effects to recreation.

Because recreation is largely dependent on water due to activities such as boating, fishing, and swimming, it is affected by both water quantity and quality. Precipitation and temperature trends would decrease water quantity. As discussed in Appendix B, Hydrology and Hydraulics, higher winter reservoir in-flows due to more precipitation falling as rain would not be stored until approximately February 1, when WVS reservoirs begin adhering to their rule curves. This would decrease the chance of reservoirs reaching the pool levels they had in previous years, which could shorten the recreational season and limit recreational availability because water (and boat ramps) could become unavailable sooner in the year. Other trends would contribute to these adverse effects: less snowpack would decrease spring reservoir inflows, and drier, hotter summers (in terms of both air and water temperatures) would increase evaporation rates and further limit water quantity. Increased temperatures, less snowpack, and more winter rain would result in lower summer river flows downstream of WVS projects, which would shorten the recreational season and decrease the quality of riverine recreation. Further, increased occurrence and severity of wildfires would substantially degrade air quality during wildfire season, which would not only decrease the quality of the recreational experience due to adverse visual impacts, but could put recreationists at risk of health effects due to wildfire smoke, which is comprised of gaseous pollutants, hazardous air pollutants (HAPs), water vapor, and particulate matter[51] (PM). PM is a main component of wildfire smoke and the principal public health threat (EPA 2021e). The severity of effects would depend on the size and proximity of the fire(s) (OHA No Date-a). During times when regional air quality from wildfire smoke is poor, the majority of recreationists are likely to forego outdoor recreation; recreational areas or part or all of the reservoir(s) may be closed.

Climate change-driven effects on water quality would also have effects on the quality of the recreational experience, although these effects would be less direct than those that would shorten the recreational season, limit recreational availability, and affect air quality as described above. Higher air and water temperatures, less water in river and reservoir systems, and more frequent and severe wildfires would decrease water quality from higher turbidity, elevated concentrations of contaminants such as mercury, and increased occurrence of harmful algal blooms (HABs). Increased occurrence of HABs would decrease dissolved oxygen (DO) concentrations and could adversely affect recreational fishing. Both elevated turbidity and increased occurrence of HABs would also contribute to adverse effects to the recreational experience through visual impacts.

Because climate change would affect water quantity and both air and water quality, effects to recreation would be direct. The water quality, flow, and upstream and downstream passage

[51] "Particulate matter" also referred to as particles or particle pollution, is a general term for a mixture of solid and liquid droplets suspended in the air.

measures of the NAA would result in negligible to major adverse effects from ongoing operation, maintenance, repair, replacement, and rehabilitation, as well as recurring drawdowns as described above. Climate change would not exacerbate effects from operation, maintenance, repair, replacement, and rehabilitation, but would exacerbate the effects from the Fall Creek drawdowns due to recurring reductions in water quantity. The NAA would also provide indirect benefits to recreational fishing by reducing TDG and normalizing temperatures at dams such as Big Cliff, Cougar, Detroit, Dexter, Fall Creek, Foster, Green Peter; however, the effects would be negligible as they would not be enough to avoid jeopardizing ESA-listed species. Climate change would further reduce these benefits by adversely impacting water quality. Over time, effects would increase in severity as water levels get lower, temperatures get higher, and air and water quality worsen. The effects of the measures under the NAA in combination with climate change on recreation would be regional in extent, minor in magnitude, but could become moderate or more severe over the life of the project; and long term.

#### *3.14.2.5 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Under Alternative 1, adverse effects from augmenting gravel below dams, maintaining or altering revetments, maintenance of existing and new fish release sites, restoring upstream and downstream passage at drop structures, and providing Pacific lamprey passage and infrastructure would range from negligible to minor in magnitude; be short term in duration; and local in extent. Adverse effects from operation, maintenance, repair, replacement, and rehabilitation would range from negligible to moderate in magnitude; be short, medium, and long term in duration and local in extent. Adverse effects from reducing minimum flows to congressionally authorized minimum flows would be minor to moderate in magnitude in the long term and localized in extent at rivers. Adverse effects from improving structures to reduce TDG, constructing WTC towers and downstream fish passage infrastructure, the Foster fish ladder temperature improvement, and constructing AFFs would range from negligible to moderate in the medium term and be local in extent. At Foster Dam only, potential adverse effects from constructing downstream fish passage infrastructure would range from negligible to minor in the short term and be local in extent from the fish weir modifications. Adverse effects from adapting the hatchery program would be negligible in magnitude in the long term and regional in extent. Adverse effects from the Fall Creek drawdown would be major, adverse, short term, and recur in the long term. The severity of short- and medium-term effects from construction on the quality of recreation (due to increases in noise levels, air emissions, and traffic as well as visual intrusions) would be dependent on the proximity of the recreator or recreational facilities to the project area. The magnitude of effects to specific recreation areas at each dam and reservoir and riverine areas in general due to construction projects are discussed below.

Indirect beneficial effects from augmenting gravel below dams, maintaining or altering revetments, restoring upstream and downstream passage at drop structures, augmenting instream flows using the inactive or power pools, continued operation of AFFs, adapting the hatchery program, improving structures to reduce TDG, constructing WTC towers and downstream fish passage infrastructure, the Foster fish ladder temperature improvement, constructing AFFs, and Fall Creek drawdowns would be minor in magnitude. The effects of these measures would all occur in the long term and be regional in extent. Direct beneficial effects from reducing minimum flows to congressionally authorized minimum flows would moderate in magnitude and local in extent at reservoirs.

Under Alternative 1, adverse effects would be less severe than alternatives 2A, 2B, 3A, 3B, 4, and 5. This is because Alternative 1 includes only one recurring drawdown and does not include the suite of near-term operations. Additionally, Alternative 1 is the only action alternative that would result in direct benefits to recreation by promoting reservoir storage (i.e., from reducing minimum flows to congressionally authorized minimum flows). All other alternatives would only result in indirect benefits to recreation over time by improving recreational fishing.

###### *3.14.2.5.1 Gravel augmentation below dams (#384), Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), Maintenance of existing and new fish release sites above dams (#726), and Restore upstream and downstream passage at drop structures (#639)*

Under all action alternatives, augmenting gravel below dams would occur below Big Cliff, Blue River, Cougar, and Foster, maintaining or altering revetments would occur basin-wide in rivers, and maintenance of existing and new fish release sites would occur basin-wide. Under Alternative 1, restoring upstream and downstream passage at drop structures would occur at Fern Ridge, but its effects are discussed generally under riverine recreation because recreational facilities at Fern Ridge would be virtually unaffected.

As discussed above in Section 3.14.2.3.1, potential adverse effects would range from negligible to minor in magnitude in the short term, and beneficial effects would be indirect and minor in magnitude in the long term. The short-term effects would be local in extent because they would be limited to the dam/reservoir or river. The long-term effects would be regional in extent because indirect benefits to recreational fishing would be perceived throughout the WVS. The magnitude of effects to specific recreation areas at each dam and reservoir and riverine areas are discussed below.

**<u>Big Cliff Dam and Reservoir</u>**

Effects would be negligible from the augmentation of gravel below the Big Cliff Dam and Reservoir because it does not have a USACE recreational facility: the only USACE recreational facility nearby is a viewpoint above the lake near the Detroit Dam, more than two miles away. While this viewpoint is a designated stop along the Mt. Jefferson section of the Oregon Cascades Birding Trail where visitors can see osprey and neotropical migrant songbirds, construction activities would be far enough away that noise would not scare birds away and decrease the recreational experience for bird watchers. None of these measures would occur near the viewpoint: augmenting gravel below dams would occur in the river below the Big Cliff Dam where there are no adjacent recreational facilities (effects to riverine recreation are discussed below). If minor structural improvements are required for the maintenance of existing or new fish release sites, any adjacent recreational facilities would experience minor effects.

**Blue River Dam and Reservoir**

The Blue River Dam and Reservoir is adjacent to one viewpoint, which would experience minor effects due to its proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. The Mona and Lookout campgrounds would experience negligible effects as these facilities would be over three miles away from these projects.

**Cougar Dam and Reservoir**

The Cougar Dam is adjacent to two viewpoints (one on either side of the dam), which would experience minor effects due to their proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. This reservoir is a designated stop along the Three Sisters section of the Oregon Cascades Birding Trail where visitors can spot American peregrine falcons around the cliffs above the reservoir. There is also a large nesting colony of Cliff Swallows southwest of the dam, where visitors can also see Violet-green and Northern Rough-winged Swallows. Visitors may also see Rock Wren, Canyon Wren, Bald Eagle, Belted Kingfisher, and waterfowl such as Bufflehead, goldeneyes, and Common and Hooded Mergansers in the fall (The Oregon Birding Trails Working Group No Date). Noise from construction activities could scare birds away and decrease the recreational experience for bird watchers. Other recreational facilities, such as Echo Park and the Slide Creek and Sunnyside campgrounds, would experience negligible effects as these facilities would be more than one and two miles away from construction, respectively. The Delta Campground is approximately two miles downstream of the Cougar Dam and is closed indefinitely due to the Holiday Farm wildfire. Because adding gravel would occur on and in the rivers below dams, the Delta Campground would experience minor effects if it reopened and construction work occurred in close proximity.

**Foster Dam and Reservoir**

Foster Dam is adjacent to Lakeshore and Andrew S. Wiley parks and Edgewater Park and Marina; and about a half mile from Shea Point. These facilities would experience minor effects due to their proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. Lewis Creek and Sunnyside parks would experience negligible effects as these facilities would be over two miles away from construction.

**Riverine Recreation**

Augmenting gravel below dams, maintaining or altering revetments, and restoring upstream and downstream passage at drop structures would occur in and on rivers, and would affect the experience for recreationists near the construction projects. As discussed above in Section

3.14.2.3.1, potential adverse effects would range from negligible to minor in magnitude in the short term: minor to a recreator passing by the project location, and negligible as the distance from the project location increases. Beneficial effects to fishing would be indirect and minor in magnitude in the long term.

*3.14.2.5.2 Provide Pacific lamprey passage and infrastructure (#52)*

Under Alternative 1, providing Pacific lamprey passage and infrastructure would occur at Fern Ridge and Green Peter. As discussed above in Section 3.14.2.3.2, potential adverse effects would range from negligible to minor in magnitude in the short term. Effects would be local in extent because they would be limited to the dam/reservoir. The severity of short-term effects on the quality of recreation would depend on the proximity of the recreational facilities to construction. The magnitude of effects to specific recreation areas are discussed below at each dam and reservoir.

**Fern Ridge Dam and Reservoir**

The Fern Ridge Dam is adjacent to Kirk and Orchard Point Parks, which would experience minor effects due to their proximity to where Pacific lamprey passage infrastructure would be provided. More specifically, increases in noise and visual intrusions would be slightly noticeable to hunters, bird-watchers, and hikers at Kirk Park. Kirk Park is one of 11 management units within the Fern Ridge Wildlife Area, which covers approximately half of the reservoir and consists of wetlands, wet prairie, oak and mixed woodlands, upland prairie, and freshwater aquatic habitats. Effects to sailing (the large surface area and consistent winds make Fern Ridge one of the best sailing reservoirs in Oregon) would not occur; effects would not be visible, audible, or otherwise felt on the reservoir because Pacific lamprey passage infrastructure would be provided on the downstream side of the dam. Effects would likely be negligible at other recreational areas like Perkins and Zumwalt parks, which would be over two miles away from construction.

**Green Peter Dam and Reservoir**

Green Peter Dam is adjacent to Billings Park and a viewpoint, which would experience minor effects due to their proximity to where Pacific lamprey passage infrastructure would be provided. Other recreational facilities, such as the Thistle Creek Boat Ramp, Whitcomb Creek Park, and Quartzville Group Camp would experience negligible effects as these facilities would be over two miles away from construction.

*3.14.2.5.3 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide.

As discussed above in Section 3.14.2.3.3, potential adverse effects from scheduled/routine maintenance would be negligible to minor in magnitude in the short and long term. Potential adverse effects from major maintenance and rehabilitation would be negligible to moderate in magnitude in the medium and long term. The short-, medium-, and long-term effects would be local in extent because they would be limited to the dam/reservoir or river.

*3.14.2.5.4 Augment instream flows by using the inactive pool (#718), Augment instream flows by using the power pool (#304), and Continued Operation of Existing AFFs*

Under Alternative 1, augmenting instream flows by using the inactive pool would occur at Blue River, Cottage Grove, Dorena, and Fall Creek; augmenting instream flows by using the power pool would occur at Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point; and continued operation of existing AFFs would occur at Dexter, Cougar, Foster, Fall Creek, and Minto at Big Cliff.

As discussed above in Section 3.14.2.3.4, beneficial effects would be indirect and minor in magnitude in the long term. Effects would be regional in extent because indirect benefits to recreational fishing would be perceived throughout the WVS.

*3.14.2.5.5 Reduce minimum flows to Congressionally authorized minimum flow requirements (#723)*

Under Alternative 1, reducing minimum flows to Congressionally authorized minimum flow requirements would occur basin-wide. As discussed above in Section 3.14.2.3.5, potential effects would be moderate and beneficial at reservoirs and minor to moderate and adverse at rivers, both in the long term. The effects would be local in extent because they would be limited to the dam/reservoir or river.

*3.14.2.5.6 Adapt Hatchery Program (#719)*

Under all action alternatives, adapting the hatchery program would occur at all hatcheries (Marion Forks, South Santiam, Leaburg, McKenzie, and Willamette). As discussed above in Section 3.14.2.3.6 (and all action alternatives), potential effects would be indirect, adverse, and negligible in the long term. Effects would be regional in extent because indirect effects to recreational fishing would occur throughout the WVS.

*3.14.2.5.7 Structural improvements to reduce total dissolved gas (#174), Construct WTC towers (#105), Construct structural downstream fish passage infrastructure (#392), Foster Fish Ladder Temperature Improvement (#479), and Construct AFFs (#722)*

Under Alternative 1, improving structures to reduce TDG would occur at Cougar, Detroit, Dexter, Foster, Green Peter, and Lookout Point; constructing WTC towers would occur at Detroit, Green Peter, and Lookout Point; constructing downstream fish passage infrastructure would occur at Detroit, Foster, Green Peter, and Lookout Point; the fish ladder temperature improvement would occur at Foster; and constructing AFFs would occur at Green Peter.

As discussed above in Section 3.14.2.3.7, potential adverse effects would range from negligible to moderate in the medium term. At Foster Dam, potential adverse effects would range from negligible to minor in the short term from the fish weir modifications. Potential beneficial effects would be indirect and minor in magnitude in the long term. The short- and medium-term effects would be local in extent because they would be limited to the dam/reservoir. The long-term effects would be regional because indirect benefits to recreational fishing would be perceived throughout the WVS. The magnitude of effects to specific recreation areas are discussed below at each dam and reservoir.

**Detroit Dam and Reservoir**

The Detroit Dam is adjacent to one viewpoint, which would experience moderate effects due to its proximity to where downstream fish passage and a WTC tower would be constructed. This dam is a designated stop along the Mt. Jefferson section of the Oregon Cascades Birding Trail where visitors can see osprey and neotropical migrant songbirds. Noise from construction activities could scare birds away and decrease the recreational experience for bird watchers. Recreational facilities on Detroit Reservoir, such as the Mongold Day Use Area and Detroit Lake State Park, would experience negligible effects as these facilities would be over two miles away from construction.

**Lookout Point and Dexter dams and reservoirs**

The Lookout Point Dam is adjacent to Meridian and Orchard parks, which would experience moderate effects due to their proximity to where downstream fish passage and a WTC tower would be constructed. Dexter Reservoir, which is directly below Lookout Point Dam, is a designated stop along the McKenzie Loop of the Willamette Valley Birding Trail where visitors can see migratory and resident songbirds and osprey and eagles along the northeast shoreline. Noise from construction activities could scare birds away and decrease the recreational experience for bird watchers. Recreational facilities on Lookout Point Reservoir, such as Landax Park and Signal Point Boat Ramp, would experience negligible effects as these facilities would be over two miles away from construction.

**Cougar, Foster, and Green Peter dams and reservoirs**

As discussed above in Section 3.14.2.3.7, changes in the quality of recreation would increase proportionally with the recreational facility's proximity to where structures would be improved to reduce TDG at Cougar and Foster, downstream fish passage infrastructure would be constructed and the fish ladder temperature improvement would occur at Foster, and an AFF would be constructed at Green Peter. The recreational experience at recreational facilities directly adjacent to Cougar, Foster, and Green Peter dams would be moderately affected. The effects on specific recreational facilities closest to and farthest from Cougar, Foster, and Green Peter dams (and therefore the construction sites) are noted above under Sections 3.14.2.5.1 and 3.14.2.5.2.

#### *3.14.2.5.8 Fall Creek drawdown*

Under all alternatives, drawdowns would continue to recur at Fall Creek. As discussed under Section 3.14.2.3.8, effects would be major, adverse, short term, and recur in the long term; and be indirect, beneficial, and minor in the long term.

Potential beneficial effects to visitation under this alternative are shown below in Table 3.14-39. Effects would be minor and beneficial at Fall Creek with approximately 4,000 more annual visitors and a 2 percent increase in total annual benefits. Fall Creek is unique from most other WVS reservoirs in that it has an unusually long boat ramp (North Shore), which extends to elevation 689 feet and would not close due to drawdowns under any of the alternatives. Thus, visitation would not decrease. As discussed above in Section 3.14.2.3.8 (Deeper fall reservoir drawdowns for downstream fish passage (#40), spring reservoir drawdown for downstream fish passage (#720); and Fall Creek drawdown), adverse effects to the recreational experience of recreationists that continue to visit the reservoir during drawdowns would be major. Adverse effects on the recreational experience would be short term and recur in the long term. Beneficial effects from improved recreational fishing would be indirect, minor in magnitude and long term at Fall Creek. The full results of visitation estimates are presented in Appendix K — Recreation Technical Report.

**Table 3.14-39. Visitation and Economic Benefits at Fall Creek Under Alternative 1**

| Dam/Reservoir | Change in Average Annual Visits | Percent Change in Total Annual Benefits | Magnitude of effects |
|---|---|---|---|
| Fall Creek | 3,000 | 1.43% | Minor beneficial |

**<u>Riverine Recreation</u>**

As discussed above in Section 3.14.2.3.8 (Deeper fall reservoir drawdowns for downstream fish passage (#40), spring reservoir drawdown for downstream fish passage (#720); and Fall Creek drawdown) drawing down reservoirs would have effects on river flows downstream of WVS reservoirs. Visitation estimates are not made for riverine areas because of the many access points available to recreators. Instead, changes in alternative flows compared to the NAA at eleven gage locations throughout the study area are used as an indicator of general effects to recreation (Appendix K — Recreation Technical Report). Higher stream flows would increase riverine recreational carrying capacities and benefit activities such as white-water rafting. Increases in water flows would also benefit fish habitat through water temperature, but could also improve riparian vegetation which would generally improve aesthetics and subsequently benefit the riverine recreational experience. Visitation estimates are not made for riverine areas because of the many access points available to recreators. Instead, changes in alternative flows compared to the NAA at eleven gage locations throughout the study area are used as an indicator of general effects to recreation. The magnitude of effects to specific rivers or river reaches are shown below in Table 3.14-40.

**Table 3.14-40. Percent Change in Flows and Magnitude of Effects on the Coast Fork Willamette, Long Tom, McKenzie, Middle Fork Willamette, Middle Willamette, North Santiam, South Santiam, and Upper Willamette rivers Under Alternative 1**

| River Gage | Season | Percent Change in Flows from No Action | Magnitude of effects |
|---|---|---|---|
| **Coast Fork Willamette River** | | | |
| Goshen | Fall/Winter average | 0.94% | Negligible beneficial |
| | Spring/Summer average | 1.13% | Minor beneficial |
| **Long Tom River** | | | |
| Monroe | Fall/Winter average | -0.02% | Negligible adverse |
| | Spring/Summer average | 0.13% | Negligible beneficial |
| **McKenzie River** | | | |
| Vida | Fall/Winter average | 0.77% | Negligible beneficial |
| | Spring/Summer average | -0.05% | Negligible adverse |
| **Middle Fork Willamette River** | | | |
| Jasper | Fall/Winter average | 0.38% | Negligible beneficial |
| | Spring/Summer average | 2.01% | Minor beneficial |
| **Middle Willamette River** | | | |
| Salem | Fall/Winter average | 1.13% | Minor beneficial |
| | Spring/Summer average | -0.90% | Negligible adverse |
| **North Santiam River** | | | |
| Jefferson and Mehama average | Fall/Winter average | 2.03% | Minor beneficial |
| | Spring/Summer average | -5.57% | Moderate adverse |
| **South Santiam River** | | | |
| Waterloo | Fall/Winter average | 4.11% | Minor beneficial |
| | Spring/Summer average | -12.08% | Moderate adverse |
| **Upper Willamette River** | | | |
| Albany, Eugene, and Harrisburg averages | Fall/Winter average | 0.45% | Negligible beneficial |
| | Spring/Summer average | 1.90% | Minor beneficial |

##### *3.14.2.5.9 Climate Change*

Alternative 1 would combine storage-focused measures in order to improve fish passage. As discussed above in Section 3.14.2.4.1, climate change is expected to adversely affect water quantity and air and water quality. The measures in Alternative 1 would improve reservoir storage (water quantity) and improve water quality by reducing TDG and normalizing temperatures. Therefore, the effects of climate change on recreation would be less severe under Alternative 1 than any other alternative, including the NAA. Climate change in combination with the measures under Alternative 1 would have direct, adverse, negligible to minor, regional effects to recreation in the long term.

#### ***3.14.2.6 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative***

Under Alternative 2A, adverse effects from augmenting gravel below dams, maintaining or altering revetments, maintenance of existing and new fish release sites, and providing Pacific lamprey passage and infrastructure would range from negligible to minor in magnitude; be short term in duration; and local in extent. Adverse effects from operation, maintenance, repair, replacement, and rehabilitation would range from negligible to moderate in magnitude; be short, medium, and long term in duration and local in extent. Adverse effects from constructing WTC towers and downstream fish passage infrastructure, the Foster fish ladder temperature improvement, and constructing AFFs would range from negligible to moderate in the medium term and be local in extent. At Foster Dam only, potential adverse effects from constructing downstream fish passage infrastructure would range from negligible to minor in the short term and be local in extent from the fish weir modifications. Adverse effects from adapting the hatchery program would be negligible in magnitude in the long term and regional in extent. Adverse effects from the deeper fall reservoir drawdown, Fall Creek drawdown, and suite of near-term operations would be major (moderate at Foster from the near-term operations), adverse, short term, and recur in the long term. The severity of short- and medium-term effects from construction on the quality of recreation (due to increases in noise levels, air emissions, and traffic as well as visual intrusions) would be dependent on the proximity of the recreator or recreational facilities to the project area. The magnitude of effects to specific recreation areas at each dam and reservoir and riverine areas in general due to construction projects are discussed below.

Indirect beneficial effects from augmenting gravel below dams, maintaining or altering revetments, augmenting instream flows using the inactive and power pools, continued operation of AFFs, integrated habitat and flow regime, adapting the hatchery program, constructing WTC towers and downstream fish passage infrastructure, the Foster fish ladder temperature improvement, constructing AFFs, deeper fall reservoir drawdowns, Fall Creek drawdowns, and suite of near-term operations would be minor in magnitude. These measures would all occur in the long term and be regional in extent.

Under Alternative 2A, adverse effects would be more severe than Alternative 1 but less severe than Alternatives 2B, 3A, 3B, 4, and 5 due to the number of recurring drawdowns.

##### *3.14.2.6.1 Gravel augmentation below dams (#384), Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), and Maintenance of existing and new fish release sites above dams (#726)*

Under all action alternatives, augmenting gravel below dams would occur below Big Cliff, Blue River, Cougar, and Foster, maintaining or altering revetments would occur basin-wide in rivers, and maintenance of existing and new fish release sites would occur basin-wide.

As discussed above in Section 3.14.2.3.1, potential adverse effects would range from negligible to minor in magnitude in the short term, and beneficial effects would be indirect and minor in magnitude in the long term. The short-term effects would be local in extent because they would be limited to the dam/reservoir or river. The long-term effects would be regional in extent because indirect benefits to recreational fishing would be perceived throughout the WVS. The magnitude of effects to specific recreation areas at each dam and reservoir and riverine areas are discussed below.

**Big Cliff Dam and Reservoir**

As discussed above in Section 3.14.2.3.1, effects would be negligible at Big Cliff Dam and Reservoir because augmenting gravel below dams and maintaining or altering revetments would occur in rivers, and Big Cliff Dam and Reservoir does not have designated recreational facilities within two miles of the river.

**Blue River Dam and Reservoir**

As discussed above in Section 3.14.2.3.1, the Blue River Dam and Reservoir is adjacent to one viewpoint, which would experience minor effects due to its proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. The Mona and Lookout campgrounds would experience negligible effects as these facilities would be over three miles away from construction.

**Cougar Dam and Reservoir**

As discussed above in Section 3.14.2.3.1, the Cougar Dam is adjacent to two viewpoints, which would experience minor effects due to their proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. Other recreational facilities, such as Echo Park and the Slide Creek and Sunnyside campgrounds, would experience negligible effects as these facilities would be over one or two miles away from construction, respectively. The Delta Campground is approximately two miles downstream of the Cougar Dam and is closed indefinitely due to the Holiday Farm wildfire. Because augmenting gravel would occur on and in the rivers below dams, the Delta Campground would experience minor effects if it reopened and construction work occurred in close proximity.

**Foster Dam and Reservoir**

As discussed above in Section 3.14.2.3.1, Foster Dam is adjacent to Lakeshore and Andrew S. Wiley parks, and Edgewater Park and Marina; and about a half mile from Shea Point. These facilities would experience minor effects due to their proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. Lewis Creek and Sunnyside parks would experience negligible effects as these facilities would be over two miles away from construction.

**Riverine Recreation**

As discussed above in Section 3.14.2.3.1, augmenting gravel below dams and maintaining or altering revetments would occur in and on rivers, and would affect the experience for recreationists at or near the construction projects. Potential adverse effects would range from negligible to minor in magnitude in the short term: minor to a recreator passing by the project location, and negligible as the distance from the project location increases. Beneficial effects would be indirect and minor in magnitude in the long term.

*3.14.2.6.2 Provide Pacific Lamprey Passage and Infrastructure (#52)*

Under Alternative 2A, providing Pacific lamprey passage and infrastructure would occur at Green Peter. As discussed above in Section 3.14.2.3.2, potential adverse effects would range from negligible to minor in magnitude in the short term. Effects would be local in extent because they would be limited to the dam/reservoir. The magnitude of effects to specific recreation areas are discussed below at Green Peter.

**Green Peter Dam and Reservoir**

Green Peter Dam is adjacent to Billings Park and a viewpoint, which would experience minor effects due to their proximity to where Pacific lamprey passage and infrastructure would be provided. Other recreational facilities, such as the Thistle Creek Boat Ramp and Whitcomb Creek Park, would experience negligible effects as these facilities would be over two miles away from construction.

*3.14.2.6.3 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide.

As discussed above in Section 3.14.2.3.3, potential adverse effects from scheduled/routine maintenance would be negligible to minor in magnitude in the short and long term. Potential adverse effects from major maintenance and rehabilitation would be negligible to moderate in magnitude in the medium and long term. The short-, medium-, and long-term effects would be local in extent because they would be limited to the dam/reservoir or river.

##### *3.14.2.6.4 Integrated temperature and habitat flow regime (#30a), Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166), Augment instream flows by using the inactive pool (#718), Augment instream flows by using the power pool (#304), Pass water over spillway in spring for fish passage (#714), and Continued Operation of Existing AFFs*

Under Alternative 2A, the integrated habitat and flow regime would occur basin-wide; using ROs to discharge colder water would occur at Green Peter, augmenting instream flows by using the inactive pool would occur at Blue River and Fall Creek; augmenting instream flows by using the power pool would occur at Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point; passing water over the spillway in the spring for fish passage would occur at Green Peter, and continuing operations of existing AFFs would occur at Dexter, Cougar, Foster, Fall Creek, and Minto at Big Cliff.

As discussed above in Section 3.14.2.3.4, beneficial effects would be indirect and minor in magnitude in the long term. Effects would be regional in extent because indirect benefits to recreational fishing would be perceived throughout the WVS.

##### *3.14.2.6.5 Adapt Hatchery Program (#719)*

Under all action alternatives, adapting the hatchery program would occur at all hatcheries (Marion Forks, South Santiam, Leaburg, McKenzie, and Willamette). As discussed above in Section 3.14.2.3.6, potential effects would be indirect, adverse, and negligible in the long term. Effects would be regional in extent because indirect effects to recreational fishing would occur throughout the WVS.

##### *3.14.2.6.6 Construct WTC towers (#105), Construct structural downstream fish passage infrastructure (#392), Foster Fish Ladder Temperature Improvement (#479), and Construct AFFs (#722)*

Under Alternative 2A, constructing a WTC tower would occur at Detroit; constructing structural downstream fish passage infrastructure would occur at Cougar, Detroit, Foster, and Lookout Point; the fish ladder temperature improvement would occur at Foster; and constructing AFFs would occur at Green Peter.

As discussed above in Section 3.14.2.3.7, potential adverse effects would range from negligible to moderate in the medium term. At Foster Dam, potential adverse effects would range from negligible to minor in the short term from the fish weir modifications. The short- and medium-term effects would be local in extent because they would be limited to the dam/reservoir. Potential beneficial effects would be indirect and minor in magnitude in the long term. The long-term effects would be regional because indirect benefits to recreational fishing would be perceived throughout the WVS. The magnitude of effects to specific recreation areas are discussed below at each dam and reservoir.

**Detroit Dam and Reservoir**

The Detroit Dam is adjacent to one viewpoint, which would experience moderate effects due to its proximity to where downstream fish passage and a WTC tower would be constructed. This dam is a designated stop along the Mt. Jefferson section of the Oregon Cascades Birding Trail where visitors can see osprey and neotropical migrant songbirds. Noise from construction activities could scare birds away and decrease the recreational experience for bird watchers. Recreational facilities on Detroit Reservoir, such as the Mongold Day Use Area and Detroit Lake State Park, would experience negligible effects as these facilities would be over two miles away from construction.

**Lookout Point Dam and Reservoirs**

The Lookout Point Dam is adjacent to Meridian and Orchard parks, which would experience moderate effects due to their proximity to where downstream fish passage and a WTC tower would be constructed. Dexter Reservoir, which is directly below Lookout Point Dam, is a designated stop along the McKenzie Loop of the Willamette Valley Birding Trail where visitors can see migratory and resident songbirds and osprey and eagles along the northeast shoreline. Noise from construction activities could scare birds away and decrease the recreational experience for bird watchers. Recreational facilities on Lookout Point Reservoir, such as Landax Park and Signal Point Boat Ramp, would experience negligible effects as these facilities would be over two miles away from construction.

**Cougar, Foster, and Green Peter dams and reservoirs**

As discussed above in Section 3.14.2.3.7, changes in the quality of recreation would increase proportionally with the recreational facility's proximity to where downstream fish passage infrastructure would be constructed at Cougar, the fish ladder temperature improvement would occur at Foster, and an AFF would be constructed at Green Peter. The recreational experience at recreational facilities directly adjacent to Cougar, Foster, and Green Peter dams would be moderately affected. The specific recreational facilities closest to and farthest from Cougar, Foster, and Green Peter dams (and therefore the construction sites) are noted above under Sections 3.14.2.6.1 and 3.14.2.6.2.

*3.14.2.6.7 Deeper fall reservoir drawdowns for fish passage (#40), Fall Creek drawdown*

Under all action alternatives, the Fall Creek drawdown would continue to recur, and under Alternative 2A, a deeper fall reservoir drawdown would occur at Green Peter. Potential adverse effects to visitation under this alternative are shown below in Table 3.14-41. The full list of effects to visitation are available in Appendix K — Recreation Technical Report. Quantified effects would be minor and adverse at Green Peter with approximately 6,000 fewer annual visitors and a 4 percent decrease in total annual benefits; and minor and beneficial at Fall Creek with approximately 4,000 more annual visitors and a 2 percent increase in total annual benefits. Fall Creek is unique from most other WVS reservoirs in that it has an unusually long boat ramp

(North Shore) that extends to elevation 689 feet, and does not close under any of the alternatives.

As discussed above in Section 3.14.2.3.8 (Deeper fall reservoir drawdowns for downstream fish passage (#40), spring reservoir drawdown for downstream fish passage (#720); and Fall Creek drawdown), adverse effects to the experience of recreationists that continue to visit the reservoir during drawdowns would be major. Adverse effects on visitation, benefits, and the recreational experience would be short term and recur in the long term. Beneficial effects from improved recreational fishing would be indirect, minor in magnitude and long term, and regional in extent.

**Table 3.14-41. Visitation and Economic Benefits at Green Peter and Fall Creek Under Alternative 2A**

| Dam/Reservoir | Change in Average Annual Visits | Percent Change in Total Annual Benefits | Magnitude of effects |
|---|---|---|---|
| Green Peter | -6,000 | -3.65% | Minor adverse |
| Fall Creek | 4,000 | 1.80% | Minor beneficial |

<u>**Riverine Recreation**</u>

As discussed above in Section 3.14.2.3.8 (Deeper fall reservoir drawdowns for downstream fish passage (#40), spring reservoir drawdown for downstream fish passage (#720); and Fall Creek drawdown) drawing down reservoirs would have effects on river flows downstream of WVS reservoirs. Visitation estimates are not made for riverine areas because of the many access points available to recreators. Instead, changes in alternative flows compared to the NAA at eleven gage locations throughout the study area are used as an indicator of general effects to recreation. The magnitude of effects to specific rivers or river reaches are shown below in Table 3.14-42. Higher stream flows would increase riverine recreational carrying capacities and benefit activities such as white-water rafting. Increases in water flows would benefit fish habitat through water temperature, but could also improve riparian vegetation which would generally improve aesthetics and subsequently benefit the riverine recreational experience.

**Table 3.14-42. Percent Change in Flows and Magnitude of Effects on the Coast Fork Willamette, Long Tom, McKenzie, Middle Fork Willamette, Middle Willamette, North Santiam, South Santiam, and Upper Willamette rivers Under Alternative 2A**

| River Gage | Season | Percent Change in Flows from No Action | Magnitude of effects |
|---|---|---|---|
| **Coast Fork Willamette River** | | | |
| Goshen | Fall/Winter average | 0.91% | Negligible beneficial |
| | Spring/Summer average | -1.07% | Minor adverse |
| **Long Tom River** | | | |
| Monroe | Fall/Winter average | -0.02% | Negligible adverse |

| River Gage | Season | Percent Change in Flows from No Action | Magnitude of effects |
|---|---|---|---|
| | Spring/Summer average | 0.14% | Negligible beneficial |
| **McKenzie River** | | | |
| Vida | Fall/Winter average | 1.24% | Minor beneficial |
| | Spring/Summer average | -1.17% | Minor adverse |
| **Middle Fork Willamette River** | | | |
| Jasper | Fall/Winter average | 3.36% | Minor beneficial |
| | Spring/Summer average | -4.84% | Minor adverse |
| **Middle Willamette River** | | | |
| Salem | Fall/Winter average | 0.64% | Negligible beneficial |
| | Spring/Summer average | 1.70% | Minor beneficial |
| **North Santiam River** | | | |
| Jefferson and Mehama average | Fall/Winter average | -0.93% | Negligible adverse |
| | Spring/Summer average | 6.44% | Moderate beneficial |
| **South Santiam River** | | | |
| Waterloo | Fall/Winter average | -3.70% | Minor adverse |
| | Spring/Summer average | 18.65% | Moderate beneficial |
| **Upper Willamette River** | | | |
| Albany, Eugene, and Harrisburg averages | Fall/Winter average | 2.09% | Minor beneficial |
| | Spring/Summer average | -2.79% | Minor adverse |

#### *3.14.2.6.8 Suite of near-term operations*

The suite of near-term operations would be included in Alternative 2A. As discussed in Section 3.14.2.3.9, effects from the deep drawdowns at Cougar, Green Peter, Lookout Point, and Fall Creek, and the delayed refills at Fall Creek and Cougar (which would lengthen the effects of the deep drawdowns) would be major, adverse, short term, and recur in the long term. Effects of the delayed refill (with no deep drawdown) at Foster would be moderate, adverse, and recur in the long term. Effects of all other near-term operations would be indirect, beneficial, and minor in the long term. The adverse effects would be local in extent because they would be limited to the dam/reservoir, and beneficial effects to recreational fishing would be regional in extent because they would be perceived throughout the WVS.

##### *3.14.2.6.9 Climate Change*

Alternative 2A would integrate water management flexibility and ESA-listed fish measures (using structural downstream passage at Cougar Dam). As discussed above in Section 3.14.2.4.1, climate change is expected to adversely affect water quantity and air and water quality. The measures in Alternative 2A would improve water quality by reducing TDG and normalizing temperatures. It would also provide fish passage. However, it would not improve reservoir storage like Alternative 1. In general, climate change would exacerbate effects from deep drawdowns: as temperatures increase and snowpacks decline, reservoirs may struggle to reach their conservation pool elevations over time, which would indirectly and adversely affect recreation in the long term. Climate change in combination with the measures under Alternative 2A would have direct, adverse, minor to moderate, regional effects to recreation in the long term.

#### *3.14.2.7 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (using diversion tunnel at CGR)*

Under Alternative 2B, adverse effects from augmenting gravel below dams, maintaining or altering revetments, maintenance of existing and new fish release sites, and providing Pacific lamprey passage and infrastructure would range from negligible to minor in magnitude; be short term in duration; and local in extent. Adverse effects from operation, maintenance, repair, replacement, and rehabilitation would range from negligible to moderate in magnitude; be short, medium, and long term in duration and local in extent. Adverse effects from constructing WTC towers and downstream fish passage infrastructure, the Foster fish ladder temperature improvement, and constructing AFFs would range from negligible to moderate in the medium term and be local in extent. At Foster Dam only, potential adverse effects from constructing downstream fish passage infrastructure would range from negligible to minor in the short term and be local in extent from the fish weir modifications. Adverse effects from adapting the hatchery program would be negligible in magnitude in the long term and regional in extent. Adverse effects from the deeper fall reservoir drawdowns, spring reservoir drawdowns, Fall Creek drawdowns, and suite of near-term operations would be major (moderate at Foster from the near-term operations), adverse, short term, and recur in the long term. The severity of short- and medium-term effects from construction on the quality of recreation (due to increases in noise levels, air emissions, and traffic as well as visual intrusions) would be dependent on the proximity of the recreator or recreational facilities to the project area. The magnitude of effects to specific recreation areas at each dam and reservoir and riverine areas in general due to construction projects are discussed below.

Indirect beneficial effects from augmenting gravel below dams, maintaining or altering revetments, augmenting instream flows using the inactive and power pools, integrated habitat and flow regime, continued operation of AFFs, adapting the hatchery program, constructing WTC towers and downstream fish passage infrastructure, the Foster fish ladder temperature improvement, constructing AFFs, deeper fall reservoir drawdowns, spring reservoir drawdowns, Fall Creek drawdowns, and suite of near-term operations would be minor in magnitude. The effects of these measures would all occur in the long term and be regional in extent.

Under Alternative 2B, adverse effects would be the same as Alternative 5, more severe than Alternatives 1 and 2A, but less severe than Alternatives 3A, 3B, or 4 due to the number of recurring drawdowns.

*3.14.2.7.1 Gravel augmentation below dams (#384), Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), and Maintenance of existing and new fish release sites above dams (#726)*

Under all action alternatives, augmenting gravel below dams would occur below Big Cliff, Blue River, Cougar, and Foster, maintaining or altering revetments would occur basin-wide in rivers, maintenance of existing and new fish release sites would occur basin-wide.

As discussed above in Section 3.14.2.3.1, potential adverse effects would range from negligible to minor in magnitude in the short term, and beneficial effects would be indirect and minor in magnitude in the long term. The short-term effects would be local in extent because they would be limited to the dam/reservoir or river. The long-term effects would be regional in extent because indirect benefits to recreational fishing would be perceived throughout the WVS. The magnitude of effects to specific recreation areas at each dam and reservoir and riverine areas are discussed below.

**Big Cliff Dam and Reservoir**

As discussed above under the other action alternatives, effects would be negligible at Big Cliff Dam and Reservoir because augmenting gravel below dams and maintaining or altering revetments would occur in rivers, and Big Cliff Dam and Reservoir does not have designated recreational facilities within two miles of the river.

**Blue River Dam and Reservoir**

As discussed above under the other action alternatives, the Blue River Dam and Reservoir is adjacent to one viewpoint, which would experience minor effects due to their proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. The Mona and Lookout campgrounds would experience negligible effects as these facilities would be over three miles away from construction.

**Cougar Dam and Reservoir**

As discussed above under the other action alternatives, the Cougar Dam is adjacent to two viewpoints, which would experience minor effects due to their proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. Other recreational facilities, such as Echo Park and the Slide Creek and Sunnyside campgrounds, would experience negligible effects as these facilities would be over one or two miles away from construction, respectively. The Delta Campground is approximately two miles downstream of the Cougar Dam and is closed indefinitely due to the Holiday Farm wildfire. Because augmenting gravel would occur on and in the rivers below dams, the Delta Campground would experience minor effects if it reopened and construction work occurred in close proximity.

**Foster Dam and Reservoir**

As discussed above under the other action alternatives, Foster Dam is adjacent to Lakeshore and Andrew S. Wiley parks, and Edgewater Park and Marina; and about a half mile from Shea Point. These facilities would experience minor effects due to their proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. Lewis Creek and Sunnyside parks would experience negligible effects as these facilities would be over two miles away from construction.

**Riverine Recreation**

As discussed above under the other action alternatives, augmenting gravel below dams and maintaining or altering revetments would occur in and on rivers, and would affect the experience for recreationists at or near the construction projects. Potential adverse effects would range from negligible to minor in magnitude in the short term: minor to a recreator passing by the project location, and negligible as the distance from the project location increases. Beneficial effects would be indirect and minor in magnitude in the long term.

##### *3.14.2.7.2 Provide Pacific lamprey passage and infrastructure (#52)*

Under Alternative 2B, providing Pacific lamprey passage and infrastructure would occur at Green Peter. As discussed above in Section 3.14.2.3.2, potential adverse effects would range from negligible to minor in magnitude in the short term. Effects would be local in extent because they would be limited to the dam/reservoir. The magnitude of effects to specific recreation areas at Green Peter are discussed below.

**Green Peter Dam and Reservoir**

Green Peter Dam is adjacent to Billings Park and a viewpoint, which would experience minor effects due to their proximity to where Pacific lamprey passage and infrastructure would be provided. Other recreational facilities, such as the Thistle Creek Boat Ramp and Whitcomb Creek Park, would experience negligible effects as these facilities would be over two miles away from construction.

##### *3.14.2.7.3 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide.

As discussed above under the other action alternatives, potential adverse effects from scheduled/routine maintenance would be negligible to minor in magnitude in the short and long term. Potential adverse effects from major maintenance and rehabilitation would be negligible to moderate in magnitude in the medium and long term. The short-, medium-, and long-term effects would be local in extent because they would be limited to the dam/reservoir or river.

*3.14.2.7.4 Integrated temperature and habitat flow regime (#30a), Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166), Augment instream flows by using the inactive pool (#718), Augment instream flows by using the power pool (#304), Pass water over spillway in spring for fish passage (#714), and Continued Operation of Existing AFFs*

Under Alternative 2B, the integrated habitat and flow regime would occur basin-wide; using Ros to discharge colder water would occur at Green Peter, augmenting instream flows by using the inactive pool would occur at Blue River and Fall Creek; augmenting instream flows by using the power pool would occur at Detroit, Green Peter, Hills Creek, and Lookout Point; passing water over the spillway in the spring for fish passage would occur at Green Peter, and continuing operations of existing AFFs would occur at Dexter, Cougar, Foster, Fall Creek, and Minto at Big Cliff.

As discussed above in Section 3.14.2.3.4, beneficial effects would be indirect and minor in magnitude in the long term. Effects would be regional in extent because indirect benefits to recreational fishing would be perceived throughout the WVS.

*3.14.2.7.5 Adapt Hatchery Program (#719)*

Under all action alternatives, adapting the hatchery program would occur at all hatcheries (Marion Forks, South Santiam, Leaburg, McKenzie, and Willamette). As discussed above under the other action alternatives, potential effects would be indirect, adverse, and negligible in the long term. Effects would be regional in extent because indirect effects to recreational fishing would occur throughout the WVS.

*3.14.2.7.6 Construct WTC towers (#105), Construct structural downstream fish passage infrastructure (#392), Foster Fish Ladder Temperature Improvement (#479), and Construct AFFs (#722)*

Under Alternative 2B, as under Alternative 2A, constructing a WTC tower would occur at Detroit; constructing structural downstream fish passage infrastructure would occur at Detroit, Foster, and Lookout Point (this would also occur at Cougar under Alternative 2A); the fish ladder temperature improvement would occur at Foster; and constructing an AFF would occur at Green Peter.

As discussed above in Section 3.14.2.3.7, potential adverse effects would range from negligible to moderate in the medium term. At Foster Dam, potential adverse effects would range from negligible to minor in the short term from the fish weir modifications. Potential beneficial effects would be indirect and minor in magnitude in the long term. The short- and medium-term effects would be local in extent because they would be limited to the dam/reservoir. The long-term effects would be regional because indirect benefits to recreational fishing would be perceived throughout the WVS. The magnitude of effects to specific recreation areas are discussed below at each dam and reservoir.

**Detroit Dam and Reservoir**

The Detroit Dam is adjacent to one viewpoint, which would experience moderate effects due to its proximity to where downstream fish passage and a WTC tower would be constructed. This dam is a designated stop along the Mt. Jefferson section of the Oregon Cascades Birding Trail where visitors can see osprey and neotropical migrant songbirds. Noise from construction activities could scare birds away and decrease the recreational experience for bird watchers. Recreational facilities on Detroit Reservoir, such as the Mongold Day Use Area and Detroit Lake State Park, would experience negligible effects as these facilities would be over two miles away from construction.

**Lookout Point Dam and Reservoirs**

The Lookout Point Dam is adjacent to Meridian and Orchard parks, which would experience moderate effects due to their proximity to where downstream fish passage would be constructed. Dexter Reservoir, which is directly below Lookout Point Dam, is a designated stop along the McKenzie Loop of the Willamette Valley Birding Trail where visitors can see migratory and resident songbirds and osprey and eagles along the northeast shoreline. Noise from construction activities could scare birds away and decrease the recreational experience for bird watchers. Recreational facilities on Lookout Point Reservoir, such as Landax Park and Signal Point Boat Ramp, would experience negligible effects as these facilities would be over two miles away from construction.

**Foster and Green Peter dams and reservoirs**

As discussed above in Section 3.14.2.3.7, changes in the quality of recreation would increase proportionally with the recreational facility’s proximity to where downstream fish passage infrastructure would be constructed and the fish ladder temperature improvement would occur at Foster, and where an AFF would be constructed at Green Peter. The recreational experience at recreational facilities directly adjacent to Foster and Green Peter dams would be moderately affected. The specific recreational facilities closest to and farthest from Foster and Green Peter dams (and therefore the construction sites) are noted above under Sections 3.14.2.7.1 and 3.14.2.7.2.

##### *3.14.2.7.7 Deeper fall reservoir drawdowns for fish passage (#40), Spring reservoir drawdown for downstream fish passage (#720), and Fall Creek drawdown*

Under all action alternatives, the Fall Creek drawdown would continue to recur, and under Alternative 2B, fall reservoir drawdowns would occur at Cougar (to the DT) and Green Peter and a spring drawdown would occur at Cougar (to the DT). Potential adverse and beneficial effects to visitation under this alternative are shown below in Table 3.14-43. The full list of effects to visitation are available in Appendix K — Recreation Technical Report. Quantified effects would be major and adverse at Cougar with approximately 17,000 fewer annual visitors and a 42 decrease in average annual benefits; minor and adverse at Green Peter with approximately 6,000 fewer annual visitors and a 4 percent decrease in total annual benefits; and minor and beneficial at Fall Creek with 3,000 more annual visitors and a 2 percent increase in total annual benefits. Fall Creek is unique from most other WVS reservoirs in that it has an unusually long boat ramp (North Shore) that extends to elevation 689 feet, and does not close under any of the alternatives.

As discussed above in Section 3.14.2.3.8 (Deeper fall reservoir drawdowns for downstream fish passage (#40), spring reservoir drawdown for downstream fish passage (#720); and Fall Creek drawdown), adverse effects to the experience of recreationists that continue to visit the reservoir during drawdowns would be major. Adverse effects on visitation, benefits, and the recreational experience would be short term and recur in the long term. Beneficial effects from improved recreational fishing would be minor in magnitude, long term and regional in extent. Because drawing down Cougar Reservoir to the DT would require the construction of a tower and bridge in-the-dry, Alternative 2B would also have negligible to major effects in the medium term at Cougar from construction. The changes in the quality of recreation would increase proportionally with the recreational facility's proximity to the construction. Effects to the experience at recreational facilities directly adjacent to Cougar Dam would be major. The specific recreational facilities closest to and farthest from Cougar Dam (and therefore the construction sites) are noted above under Section 3.14.2.7.1.

**Table 3.14-43. Visitation and Economic Benefits at Cougar, Green Peter, and Fall Creek Under Alternative 2B**

| Dam/Reservoir | Change in Average Annual Visits | Percent Change in Total Annual Benefits | Magnitude of effects |
|---|---|---|---|
| Cougar | -17,000 | -42.38% | Major adverse |
| Green Peter | -6,000 | -3.65% | Minor adverse |
| Fall Creek | 3,000 | 1.67% | Minor beneficial |

<u>**Riverine Recreation**</u>

As discussed above in Section 3.14.2.3.8 (Deeper fall reservoir drawdowns for downstream fish passage (#40), spring reservoir drawdown for downstream fish passage (#720); and Fall Creek drawdown), drawing down reservoirs would have effects on river flows downstream of WVS reservoirs. Visitation estimates are not made for riverine areas because of the many access points available to recreators. Instead, changes in alternative flows compared to the NAA at eleven gage locations throughout the study area are used as an indicator of general effects to recreation. The magnitude of effects to specific rivers or river reaches are shown below in Table 3.14-44. Higher stream flows would increase riverine recreational carrying capacities and benefit activities such as white-water rafting. Increases in water flows would benefit fish habitat through water temperature, but could also improve riparian vegetation which would generally improve aesthetics and subsequently benefit the riverine recreational experience.

**Table 3.14-44. Percent Change in Flows and Magnitude of Effects on the Coast Fork Willamette, Long Tom, McKenzie, Middle Fork Willamette, Middle Willamette, North Santiam, South Santiam, and Upper Willamette rivers Under Alternative 2B**

| River Gage | Season | Percent Change in Flows from No Action | Magnitude of effects |
|---|---|---|---|
| **Coast Fork Willamette River** | | | |
| Goshen | Fall/Winter average | 0.80% | Negligible beneficial |
| | Spring/Summer average | -0.20% | Negligible adverse |
| **Long Tom River** | | | |
| Monroe | Fall/Winter average | -0.02% | Negligible adverse |
| | Spring/Summer average | 0.14% | Negligible beneficial |
| **McKenzie River** | | | |
| Vida | Fall/Winter average | -1.29% | Minor adverse |
| | Spring/Summer average | -1.89% | Minor adverse |
| **Middle Fork Willamette River** | | | |
| Jasper | Fall/Winter average | 1.72% | Minor beneficial |
| | Spring/Summer average | -1.48% | Minor adverse |
| **Middle Willamette River** | | | |
| Salem | Fall/Winter average | -0.27% | Negligible adverse |
| | Spring/Summer average | 2.00% | Minor beneficial |
| **North Santiam River** | | | |
| Jefferson and Mehama average | Fall/Winter average | -0.90% | Negligible adverse |
| | Spring/Summer average | 6.40% | Moderate beneficial |
| **South Santiam River** | | | |
| Waterloo | Fall/Winter average | -3.70% | Minor adverse |
| | Spring/Summer average | 18.65% | Moderate beneficial |
| **Upper Willamette River** | | | |
| Albany, Eugene, and Harrisburg averages | Fall/Winter average | 0.58% | Negligible beneficial |
| | Spring/Summer average | -1.26% | Minor adverse |

##### *3.14.2.7.8 Suite of near-term operations*

The suite of near-term operations would be included in Alternative 2B. As discussed in Section 3.14.2.3.9, effects from the deep drawdowns at Cougar, Green Peter, Lookout Point, and Fall Creek, and the delayed refills at Fall Creek and Cougar (which would lengthen the effects of the deep drawdowns) would be major, adverse, short term, and recur in the long term. Effects of the delayed refill (with no deep drawdown) at Foster would be moderate, adverse, and recur in the long term. Effects of all other near-term operations would be indirect, beneficial, and minor in the long term. The adverse effects would be local in extent because they would be limited to the dam/reservoir, and beneficial effects would be regional in extent because benefits to recreational fishing would be perceived throughout the WVS.

##### *3.14.2.7.9 Climate Change*

Alternative 2B would integrate water management flexibility and ESA-listed fish measures (using a deep drawdown to Cougar Dam's DT). As discussed above in Section 3.14.2.4.1, climate change is expected to adversely affect water quantity and air and water quality. The measures in Alternative 2B would improve water quality by reducing TDG and normalizing temperatures. It would also provide fish passage. However, it would not improve reservoir storage like Alternative 1. Due to one more deep drawdown than Alternative 2A, climate change would exacerbate the effects of Alternative 2B more than Alternatives 1 or 2A. But overall, the effects would be the same as under Alternative 2A; climate change in combination with the measures under Alternative 2B would have direct, adverse, minor to moderate, regional effects to recreation in the long term.

#### ***3.14.2.8 Alternative 3A – Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)***

Under Alternative 3A, adverse effects from augmenting gravel below dams, maintaining or altering revetments, maintenance of existing and new fish release sites, and providing Pacific lamprey passage and infrastructure would range from negligible to minor in magnitude; be short term in duration; and local in extent. Adverse effects from using the spillway for surface spill would range from negligible to moderate in magnitude; be short term in duration; and local in extent at Blue River and Hills Creek only. Adverse effects from operation, maintenance, repair, replacement, and rehabilitation would range from negligible to moderate in magnitude; be short, medium, and long term in duration and local in extent. Adverse effects from constructing AFFs would range from negligible to moderate in the medium term and be local in extent. Adverse effects from adapting the hatchery program would be negligible in magnitude in the long term and regional in extent. Adverse effects from the deeper fall reservoir drawdowns, spring reservoir drawdowns, Fall Creek drawdowns, and suite of near-term operations would be major (moderate at Foster from the near-term operations), adverse, short term, and recur in the long term. The severity of short- and medium-term effects from construction on the quality of recreation (due to increases in noise levels, air emissions, and traffic as well as visual intrusions) would be dependent on the proximity of the recreator or recreational facilities to the project area. The magnitude of effects to specific recreation areas at each dam and reservoir and riverine areas in general due to construction projects are discussed below.

Indirect beneficial effects from augmenting gravel below dams, maintaining or altering revetments, using the spillway for surface spill, augmenting instream flows using the inactive and power pools, integrated habitat and flow regime, continued operation of AFFs, adapting the hatchery program, constructing AFFs, deeper fall reservoir drawdowns, spring reservoir drawdowns, Fall Creek drawdowns, and suite of near-term operations would be minor in magnitude. The effects of these measures would all occur in the long term and be regional in extent.

Under Alternative 3A, adverse effects would be less severe than Alternative 3B but more severe than Alternatives 1, 2A, 2B, 4, and 5 due to the number of recurring drawdowns.

*3.14.2.8.1 Gravel augmentation below dams (#384), Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), Maintenance of existing and new fish release sites above dams (#726), and Use spillway for surface spill in summer (#721)*

Under all action alternatives, augmenting gravel below dams would occur below Big Cliff, Blue River, Cougar, and Foster, maintaining or altering revetments would occur basin-wide in rivers, maintenance of existing and new fish release sites would occur basin-wide; and under Alternative 3A, using the spillway for surface spill would occur at Blue River, Detroit, Foster, Green Peter, Hills Creek, and Lookout Point.

As discussed above in Section 3.14.2.3.1, potential adverse effects would range from negligible to minor in magnitude (negligible to moderate at Blue River and Hills Creek when using the surface spillway for summer spill) in the short term, and beneficial effects would be indirect and minor in magnitude in the long term. The short-term effects would be local in extent because they would be limited to the dam/reservoir or river. The long-term effects would be regional in extent because indirect benefits to recreational fishing would be perceived throughout the WVS. Under Alternative 3A, there would be adverse effects from using the spillway for surface spill at Blue River and Hills Creek only because using the spillway would require channel modifications.

**Big Cliff Dam and Reservoir**

As discussed above under the other action alternatives, effects would be negligible at Big Cliff Dam and Reservoir because augmenting gravel below dams and maintaining or altering revetments would occur in rivers, and Big Cliff Dam and Reservoir does not have designated recreational facilities within two miles of the river (effects to riverine recreation are discussed below).

**Blue River Dam and Reservoir**

As discussed above under the other action alternatives, the Blue River Dam and Reservoir is adjacent to one viewpoint, which would experience minor effects due to its proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. The viewpoint would also experience moderate effects due to its proximity the channel modifications required for using the spillway for surface spill. The Mona and Lookout campgrounds would experience negligible effects as these facilities would be over three miles away from construction.

**Cougar Dam and Reservoir**

As discussed above under the other action alternatives, the Cougar Dam is adjacent to two viewpoints, which would experience minor effects due to their proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. Other recreational facilities, such as Echo Park and the Slide Creek and Sunnyside campgrounds, would experience negligible effects as these facilities would be more than one and two miles away from construction, respectively. The Delta Campground is approximately two miles downstream of the Cougar Dam and is closed indefinitely due to the Holiday Farm wildfire. Because augmenting gravel would occur on and in the rivers below dams, the Delta Campground would experience minor effects if it reopened and construction work occurred in close proximity.

**Foster Dam and Reservoir**

As discussed above under the other action alternatives, Foster Dam is adjacent to Lakeshore and Andrew S. Wiley parks, and Edgewater Park and Marina; and about a half mile from Shea Point. These facilities would experience minor effects due to their proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. Lewis Creek and Sunnyside parks would experience negligible effects as these facilities would be over two miles away from construction.

**Hills Creek Dam and Reservoir**

Hills Creek Dam is adjacent to two viewpoints (one on either side of the dam), which would experience moderate effects due to their proximity to where the channel would be modified to use the spillway for surface spill. This reservoir is a designated stop along the Three Sisters section of the Oregon Cascades Birding Trail, and noise from construction activities could scare birds away and decrease the recreational experience for bird watchers. The 27-mile Middle Fork Willamette Trail also borders the Hills Creek Reservoir, and construction activities could decrease the experience for recreationists such as hikers, horseback riders, and mountain bikers. Other recreational facilities, such as the Packard Creek Campground and Bingham Boat Ramp, would experience negligible effects as these facilities would be over two miles away from construction.

**Riverine Recreation**

As discussed above under the other action alternatives, augmenting gravel below dams and maintaining or altering revetments would occur in and on rivers, and would affect the experience for recreationists at or near the construction projects. Potential adverse effects would range from negligible to minor in magnitude in the short term: minor to a recreator passing by the project location, and negligible as the distance from the project location increases. Beneficial effects would be indirect and minor in magnitude in the long term.

##### *3.14.2.8.2 Provide Pacific lamprey passage and infrastructure (#52)*

Under Alternative 3A, providing Pacific lamprey passage and infrastructure would occur at Blue River, Green Peter, and Hills Creek.

As discussed above in Section 3.14.2.3.2, potential adverse effects would range from negligible to minor in magnitude in the short term. Effects would be local in extent because they would be limited to the dam/reservoir. The magnitude of effects to specific recreation areas are discussed below at each dam and reservoir.

**Green Peter Dam and Reservoir**

Green Peter Dam is adjacent to Billings Park and a viewpoint, which would experience minor effects due to their proximity to where Pacific lamprey passage and infrastructure would be provided. Other recreational facilities, such as the Thistle Creek Boat Ramp and Whitcomb Creek Park, would experience negligible effects as these facilities would be over two miles away from construction.

**Blue River and Hills Creek dams and reservoirs**

As discussed above in Section 3.14.2.3.2, changes in the quality of recreation would increase proportionally with the recreational facility's proximity to where Pacific lamprey passage and infrastructure would be provided. The recreational experience at recreational facilities directly adjacent to Blue River and Hills Creek dams would experience minor effects. The specific recreational facilities closest to and farthest from Blue River and Hills Creek dams (and therefore the construction sites) are noted above under Section 3.14.2.8.1.

##### *3.14.2.8.3 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide.

As discussed above under the other action alternatives, potential adverse effects from scheduled/routine maintenance would be negligible to minor in magnitude in the short and long term. Potential adverse effects from major maintenance and rehabilitation would be negligible to moderate in magnitude in the medium and long term. The short-, medium-, and long-term effects would be local in extent because they would be limited to the dam/reservoir or river.

#### *3.14.2.8.4 Integrated temperature and habitat flow regime (#30a), Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166), Augment instream flows by using the inactive pool (#718), Augment instream flows by using the power pool (#304), Pass water over spillway in spring for fish passage (#714), and Continued Operation of Existing AFFs*

Under Alternative 3A, the integrated habitat and flow regime would occur basin-wide; using ROs to discharge colder water would occur at Detroit, Green Peter, and Lookout Point, augmenting instream flows by using the inactive pool would occur at Blue River, Cottage Grove, Dorena, and Fall Creek; augmenting instream flows by using the power pool would occur at Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point; passing water over the spillway in the spring for fish passage would occur at Big Cliff, Dexter, Falls Creek, Green Peter, and Hills Creek, and continuing operations of existing AFFs would occur at Dexter, Cougar, Foster, Fall Creek, and Minto at Big Cliff.

As discussed above in Section 3.14.2.3.4, beneficial effects would be indirect and minor in magnitude in the long term. Effects would be regional in extent because indirect benefits to recreational fishing would be perceived throughout the WVS.

#### *3.14.2.8.5 Adapt Hatchery Program (#719)*

Under all action alternatives, adapting the hatchery program would occur at all hatcheries (Marion Forks, South Santiam, Leaburg, McKenzie, and Willamette). As discussed above under the other action alternatives, potential effects would be indirect, adverse, and negligible in the long term. Effects would be regional in extent because indirect effects to recreational fishing would occur throughout the WVS.

#### *3.14.2.8.6 Construct AFFs (#722)*

Under Alternative 3A, constructing AFFs would occur at Blue River, Green Peter, and Hills Creek.

As discussed above in Section 3.14.2.3.7, potential adverse effects would range from negligible to moderate in the medium term. Potential beneficial effects would be indirect and minor in magnitude in the long term. The medium-term effects would be local in extent because they would be limited to the dam/reservoir. The long-term effects would be regional because indirect benefits to recreational fishing would be perceived throughout the WVS. The magnitude of effects to specific recreation areas are discussed below at each dam and reservoir.

**Blue River, Green Peter, and Hills Creek dams and reservoirs**

As discussed above in Section 3.14.2.3.7, changes in the quality of recreation would increase proportionally with the recreational facility's proximity to where AFFs would be constructed. The recreational experience at recreational facilities directly adjacent to Blue River, Green Peter, and Hills Creek dams would experience moderate effects. The specific recreational facilities closest to and farthest from Blue River, Green Peter, and Hills Creek dams (and therefore the construction sites) are noted above under Sections 3.14.2.8.1 and 3.14.2.8.2.

##### *3.14.2.8.7 Deeper fall reservoir drawdowns for fish passage (#40), Spring reservoir drawdown for downstream fish passage (#720), and Fall Creek drawdown*

Under all action alternatives, the Fall Creek drawdown would continue to recur, and under Alternative 3A, fall reservoir drawdowns would occur at Blue River, Cougar (to the RO), Detroit, Green Peter, Hills Creek, and Lookout Point, and spring reservoir drawdowns would occur at Cougar (to the RO), Detroit, and Lookout Point.

Potential adverse and beneficial effects to visitation under this alternative are shown below in Table 3.14-45. The full list of effects to visitation are available in Appendix K — Recreation Technical Report. The quantitative effects would be major and adverse at Cougar, Lookout Point, and Detroit, with approximately 17,000, 40,000, and 63,000 fewer annual visitors and an approximately 42, 48, and 43 percent decrease in total annual benefits (respectively). Effects would be minor and adverse at Green Peter with approximately 6,000 fewer annual visitors and an approximately 4 percent decrease in total annual benefits. Quantified effects would be negligible and beneficial at Hills Creek with no or little change in visitation (due to rounding) and a less than one percent increase in total annual benefits; negligible and adverse at Blue River with no or little change in visitation (due to rounding) and a less than one percent decrease in total annual benefits; and minor and beneficial at Fall Creek with 3,000 more annual visitors and a 2 percent increase in total annual benefits.

As discussed above in Section 3.14.2.3.8 (Deeper fall reservoir drawdowns for downstream fish passage (#40), spring reservoir drawdown for downstream fish passage (#720); and Fall Creek drawdown), adverse qualitative effects to the experience of recreationists that continue to visit the reservoir during drawdowns would be major. Adverse effects on visitation, benefits, and the recreational experience would be short term and recur in the long term. Indirect, beneficial effects from improved recreational fishing would be minor in magnitude, long term, and regional in extent.

**Table 3.14-45. Visitation and Economic Benefits at Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point Under Alternative 3A**

| Dam/Reservoir | Change in Average Annual Visits | Percent Change in Total Annual Benefits | Magnitude of effects |
|---|---|---|---|
| Cougar | -17,000 | -42.38% | Major adverse |
| Green Peter | -6,000 | -3.65% | Minor adverse |
| Hills Creek[1] | 0 | 0.21% | Negligible beneficial |
| Lookout Point | -40,000 | -48.43% | Major adverse |
| Detroit | -63,000 | -40.11% | Major adverse |
| Blue River[1] | 0 | -0.71% | Negligible adverse |
| Fall Creek | 2,000 | 1.17% | Minor beneficial |

[1] Some locations show no change in the number of average annual visits due to rounding.

**Riverine Recreation**

As discussed above in Section 3.14.2.3.8 (Deeper fall reservoir drawdowns for downstream fish passage (#40), spring reservoir drawdown for downstream fish passage (#720); and Fall Creek drawdown), drawing down reservoirs would have effects on river flows downstream of WVS reservoirs. Visitation estimates are not made for riverine areas because of the many access points available to recreators. Instead, changes in alternative flows compared to the NAA at eleven gage locations throughout the study area are used as an indicator of general effects to recreation. The magnitude of effects to specific rivers or river reaches are shown below in Table 3.14-46. Higher stream flows would increase riverine recreational carrying capacities and benefit activities such as white-water rafting. Increases in water flows would benefit fish habitat through water temperature, but could also improve riparian vegetation which would generally improve aesthetics and subsequently benefit the riverine recreational experience.

**Table 3.14-46. Percent Change in Flows and Magnitude of Effects on the Coast Fork Willamette, Long Tom, McKenzie, Middle Fork Willamette, Middle Willamette, North Santiam, South Santiam, and Upper Willamette rivers Under Alternative 3A**

| River Gage | Season | Percent Change in Flows from No Action | Magnitude of effects |
|---|---|---|---|
| **Coast Fork Willamette River** | | | |
| Goshen | Fall/Winter average | -0.21% | Negligible adverse |
| | Spring/Summer average | 5.35% | Minor beneficial |
| **Long Tom River** | | | |
| Monroe | Fall/Winter average | -0.02% | Negligible adverse |
| | Spring/Summer average | 0.14% | Negligible beneficial |
| **McKenzie River** | | | |
| Vida | Fall/Winter average | -1.58% | Minor adverse |

| River Gage | Season | Percent Change in Flows from No Action | Magnitude of effects |
|---|---|---|---|
| | Spring/Summer average | -0.64% | Negligible adverse |
| **Middle Fork Willamette River** | | | |
| Jasper | Fall/Winter average | -1.69% | Minor adverse |
| | Spring/Summer average | -2.87% | Minor adverse |
| **Middle Willamette River** | | | |
| Salem | Fall/Winter average | -2.76% | Minor adverse |
| | Spring/Summer average | -0.43% | Negligible adverse |
| **North Santiam River** | | | |
| Jefferson and Mehama average | Fall/Winter average | -4.59% | Minor adverse |
| | Spring/Summer average | 0.97% | Negligible beneficial |
| **South Santiam River** | | | |
| Waterloo | Fall/Winter average | -3.70% | Minor adverse |
| | Spring/Summer average | 18.65% | Moderate beneficial |
| **Upper Willamette River** | | | |
| Albany, Eugene, and Harrisburg averages | Fall/Winter average | -2.04% | Minor adverse |
| | Spring/Summer average | -3.06% | Minor adverse |

#### *3.14.2.8.8 Suite of near-term operations*

The suite of near-term operations would be included in Alternative 3A. As discussed in Section 3.14.2.3.9, effects from the deep drawdowns at Cougar, Green Peter, Lookout Point, and Fall Creek, and the delayed refills at Fall Creek and Cougar (which would lengthen the effects of the deep drawdowns) would be major, adverse, short term, and recur in the long term. Effects of the delayed refill (with no deep drawdown) at Foster would be moderate, adverse, and recur in the long term. Effects of all other near-term operations would be indirect, beneficial, and minor in the long term. The adverse effects would be local in extent because they would be limited to the dam/reservoir, and beneficial effects would be regional in extent because benefits to recreational fishing would be perceived throughout the WVS.

#### *3.14.2.8.9 Climate Change*

Alternative 3A would improve fish passage by using operations-focused measures (using a deep drawdown to Cougars Dam's RO). As discussed above in Section 3.14.2.4.1, climate change is expected to adversely affect water quantity and air and water quality. The measures in Alternative 3A would improve water quality by normalizing temperatures. It would also provide fish passage with numerous deep drawdowns. Alternatives 3A and 3B would include more than twice as many drawdowns as the other alternatives, and Alternative 3A would include the less-deep drawdown to the Cougar RO. Due to the number of deep drawdowns, climate change would exacerbate the effects of Alternative 3A more than under Alternatives 1, 2A, 2B, 4, and 5, and less than Alternative 3B (but not appreciably). Climate change in combination with the measures under Alternative 3A would have direct, adverse, minor to moderate, regional effects to recreation in the long term.

#### *3.14.2.9 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)*

Under Alternative 3B, adverse effects from augmenting gravel below dams, maintaining or altering revetments, maintenance of existing and new fish release sites, and providing Pacific lamprey passage and infrastructure would range from negligible to minor in magnitude; be short term in duration; and local in extent. Adverse effects from using the spillway for surface spill would range from negligible to moderate in magnitude; be short term in duration; and local in extent at Blue River and Hills Creek only. Adverse effects from operation, maintenance, repair, replacement, and rehabilitation would range from negligible to moderate in magnitude; be short, medium, and long term in duration and local in extent. Adverse effects from constructing AFFs (and the deeper fall drawdowns to Cougar's DT from dam modifications) would range from negligible to moderate in the medium term and be local in extent. Adverse effects from adapting the hatchery program would be negligible in magnitude in the long term and regional in extent. Adverse effects from the deeper fall reservoir drawdowns, spring reservoir drawdowns, Fall Creek drawdowns, and suite of near-term operations would be major (moderate at Foster from the near-term operations), adverse, short term, and recur in the long term. The severity of short- and medium-term effects from construction on the quality of recreation (due to increases in noise levels, air emissions, and traffic as well as visual intrusions) would be dependent on the proximity of the recreator or recreational facilities to the project area. The magnitude of effects to specific recreation areas at each dam and reservoir and riverine areas in general due to construction projects are discussed below.

Indirect beneficial effects from augmenting gravel below dams, maintaining or altering revetments, using the spillway for surface spill, augmenting instream flows using the inactive and power pools, integrated habitat and flow regime, continued operation of AFFs, adapting the hatchery program, constructing AFFs, deeper fall reservoir drawdowns, spring reservoir drawdowns, Fall Creek drawdowns, and suite of near-term operations would be minor in magnitude. The effects of these measures would all occur in the long term and be regional in extent.

Under Alternative 3B, adverse effects would be more severe than any other action alternative because it would involve the most recurring drawdowns, including the deeper drawdown to Cougar's DT. Alternative 3B would only be slightly more adverse than Alternative 3A as they would involve the same number of recurring drawdowns, but Alternative 3B would also require the construction of the tower and bridge in order to draw-down Cougar Reservoir to the DT.

##### *3.14.2.9.1 Gravel augmentation below dams (#384), Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), Maintenance of existing and new fish release sites above dams (#726), and Use spillway for surface spill in summer (#721)*

Under all action alternatives, augmenting gravel below dams would occur below Big Cliff, Blue River, Cougar, and Foster, maintaining or altering revetments would occur basin-wide in rivers, maintenance of existing and new fish release sites would occur basin-wide; and under Alternative 3B, using the spillway for surface spill would occur at Blue River, Detroit, Foster, Green Peter, Hills Creek, and Lookout Point.

As discussed above in Section 3.14.2.3.1, potential adverse effects would range from negligible to minor in magnitude (negligible to moderate at Blue River and Hills Creek when using the surface spillway for summer spill) in the short term, and beneficial effects would be indirect and minor in magnitude in the long term. The short-term effects would be local in extent because they would be limited to the dam/reservoir or river. The long-term effects would be regional in extent because indirect benefits to recreational fishing would be perceived throughout the WVS. Under Alternative 3B, there would be adverse effects from using the spillway for surface spill at Blue River and Hills Creek only because using the spillway would require channel modifications.

**Big Cliff Dam and Reservoir**

As discussed above under the other action alternatives, effects would be negligible at Big Cliff Dam and Reservoir because augmenting gravel below dams and maintaining or altering revetments would occur in rivers, and Big Cliff Dam and Reservoir does not have designated recreational facilities within two miles of the river.

**Blue River Dam and Reservoir**

As discussed above under the other action alternatives, the Blue River Dam and Reservoir is adjacent to one viewpoint, which would experience minor effects due to its proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. The viewpoint would also experience moderate effects due to its proximity the channel modifications required for using the spillway for surface spill. The Mona and Lookout campgrounds would experience negligible effects as these facilities would be over three miles away from construction.

**Cougar Dam and Reservoir**

As discussed above under the other action alternatives, the Cougar Dam is adjacent to two viewpoints, which would experience minor effects due to their proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. Other recreational facilities, such as Echo Park and the Slide Creek and Sunnyside campgrounds, would experience negligible effects as these facilities would be over one or two miles away from construction, respectively. The Delta Campground is approximately two miles downstream of the Cougar Dam and is closed indefinitely due to the Holiday Farm wildfire. Because augmenting gravel would occur on and in the rivers below dams, the Delta Campground would experience minor effects if it reopened and construction work occurred in close proximity.

**Foster Dam and Reservoir**

As discussed above under the other action alternatives, Foster Dam is adjacent to Lakeshore and Andrew S. Wiley parks, and Edgewater Park and Marina; and about a half mile from Shea Point. These facilities would experience minor effects due to their proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. Lewis Creek and Sunnyside parks would experience negligible effects as these facilities would be over two miles away from construction.

**Hills Creek Dam and Reservoir**

Hills Creek Dam is adjacent to two viewpoints (one on either side of the dam), which would experience moderate effects due to their proximity to where the channel would be modified to use the spillway for surface spill. This reservoir is a designated stop along the Three Sisters section of the Oregon Cascades Birding Trail, and noise from construction activities could scare birds away and decrease the recreational experience for bird watchers. The 27-mile Middle Fork Willamette Trail also borders the Hills Creek Reservoir, and construction activities could decrease the experience for recreationists such as hikers, horseback riders, and mountain bikers. Other recreational facilities, such as the Packard Creek Campground and Bingham Boat Ramp, would experience negligible effects as these facilities would be over two miles away from construction.

**Riverine Recreation**

As discussed above under the other action alternatives, augmenting gravel below dams and maintaining or altering revetments would occur in and on rivers, and would affect the recreational experience at or near the construction projects. Potential adverse effects would range from negligible to minor in magnitude in the short term: minor to a recreator passing by the project location, and negligible as the distance from the project location increases. Beneficial effects would be indirect and minor in magnitude in the long term.

#### *3.14.2.9.2 Provide Pacific lamprey passage and infrastructure (#52)*

Under Alternative 3B, providing Pacific lamprey passage and infrastructure would occur at Blue River, Green Peter, and Hills Creek.

As discussed above in Section 3.14.2.3.2, potential adverse effects would range from negligible to minor in magnitude in the short term. Effects would be local in extent because they would be limited to the dam/reservoir. The magnitude of effects to specific recreation areas are discussed below at each dam and reservoir.

**Green Peter Dam and Reservoir**

Green Peter Dam is adjacent to Billings Park and a viewpoint, which would experience minor effects due to their proximity to where Pacific lamprey passage and infrastructure would be provided. Other recreational facilities, such as the Thistle Creek Boat Ramp and Whitcomb Creek Park, would experience negligible effects as these facilities would be over two miles away from construction.

**Blue River and Hills Creek dams and reservoirs**

As discussed above in Section 3.14.2.3.2, changes in the quality of recreation would increase proportionally with the recreational facility's proximity to where Pacific lamprey passage and infrastructure would be provided. The recreational experience at recreational facilities directly adjacent to Blue River and Hills Creek dams would experience minor effects. The specific recreational facilities closest to and farthest from Blue River and Hills Creek dams (and therefore the construction sites) are noted above under Section 3.14.2.9.1.

*3.14.2.9.3 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide.

As discussed above under the other action alternatives, potential adverse effects from scheduled/routine maintenance would be negligible to minor in magnitude in the short and long term. Potential adverse effects from major maintenance and rehabilitation would be negligible to moderate in magnitude in the medium and long term. The short-, medium-, and long-term effects would be local in extent because they would be limited to the dam/reservoir or river.

*3.14.2.9.4 Integrated temperature and habitat flow regime (#30a), Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166), Augment instream flows by using the inactive pool (#718), Augment instream flows by using the power pool (#304), Pass water over spillway in spring for fish passage (#714), and Continued Operation of Existing AFFs*

Under Alternative 3B, the integrated habitat and flow regime would occur basin-wide; using ROs to discharge colder water would occur at Detroit, Green Peter, and Lookout Point, augmenting instream flows by using the inactive pool would occur at Blue River, Cottage Grove, Dorena, and Fall Creek; augmenting instream flows by using the power pool would occur at Detroit, Green Peter, Hills Creek, and Lookout Point; passing water over the spillway in the spring for fish passage would occur at Big Cliff, Detroit, Dexter, and Lookout Point, and continuing operations of existing AFFs would occur at Dexter, Cougar, Foster, Fall Creek, and Minto at Big Cliff.

As discussed above in Section 3.14.2.3.4, beneficial effects would be indirect and minor in magnitude in the long term. Effects would be regional in extent because indirect benefits to recreational fishing would be perceived throughout the WVS.

*3.14.2.9.5 Adapt Hatchery Program (#719)*

Under all action alternatives, adapting the hatchery program would occur at all hatcheries (Marion Forks, South Santiam, Leaburg, McKenzie, and Willamette). As discussed above under the other action alternatives, potential effects would be indirect, adverse, and negligible in the long term. Effects would be regional in extent because indirect effects to recreational fishing would occur throughout the WVS.

*3.14.2.9.6 Construct AFFs (#722)*

Under Alternative 3B, constructing AFFs would occur at Blue River, Green Peter, and Hills Creek.

As discussed above in Section 3.14.2.3.7, potential adverse effects would range from negligible to moderate in the medium term. Potential beneficial effects would be indirect and minor in magnitude in the long term. The medium-term effects would be local in extent because they would be limited to the dam/reservoir. The long-term effects would be regional because indirect benefits to recreational fishing would be perceived throughout the WVS. The magnitude of effects to specific recreation areas are discussed below at each dam and reservoir.

**Blue River Green Peter, and Hills Creek dams and reservoirs**

As discussed above in Section 3.14.2.3.7, changes in the quality of recreation would increase proportionally with the recreational facility's proximity to where AFFs would be constructed. The recreational experience at recreational facilities directly adjacent to Blue River, Green Peter, and Hills Creek dams would experience moderate effects. The specific recreational facilities closest to and farthest from Blue River, Green Peter, and Hills Creek dams (and therefore the construction sites) are noted above under Sections 3.14.2.9.1 and 3.14.2.9.2.

*3.14.2.9.7 Deeper fall reservoir drawdowns for fish passage (#40), Spring reservoir drawdown for downstream fish passage (#720), and Fall Creek drawdown*

Under all action alternatives, the Fall Creek drawdown would continue to recur, and under Alternative 3B, fall reservoir drawdowns would occur at Blue River, Cougar (to the DT), Detroit, Green Peter, Hills Creek, and Lookout Point, and spring reservoir drawdowns would occur at Cougar (to the DT), Green Peter, and Hills Creek.

Potential adverse and beneficial effects to visitation under this alternative are shown below in Table 3.14-47. The full list of effects to visitation are available in Appendix K — Recreation

Technical Report. Quantified effects would be major and adverse at Blue River, Cougar, Green Peter, and Hills Creek with approximately 6,000, 17,000, 93,000, and 9,000 fewer annual visitors and an approximately 36, 42, 55, and 35 percent decrease in total annual benefits (respectively). Quantified effects would be moderate and adverse at Lookout Point with approximately 7,000 fewer annual visitors and an approximately 8 percent decrease in total annual benefits; minor and adverse at Detroit with approximately 8,000 fewer visitors and an approximately 5 percent decrease in total annual benefits, and minor and beneficial at Fall Creek with 3,000 more annual visitors and a 1.36 percent increase in total annual benefits.

As discussed above in Section 3.14.2.3.8 (Deeper fall reservoir drawdowns for downstream fish passage (#40), spring reservoir drawdown for downstream fish passage (#720); and Fall Creek drawdown), adverse effects to the experience of recreationists that continue to visit the reservoir during drawdowns would be major. Adverse effects on visitation, benefits, and the recreational experience would be short term and recur in the long term. Because drawing down Cougar Reservoir to the DT would require the construction of a tower and bridge in-the-dry, Alternative 3B would also have negligible to major effects in the medium term at Cougar. The changes in the quality of recreation would increase proportionally with the recreational facility's proximity to the construction. Effects to the recreational experience at facilities directly adjacent to Cougar Dam would be major. The specific recreational facilities closest to and farthest from Cougar Dam (and therefore the construction sites) are noted above under Section 3.14.2.9.1. Beneficial indirect effects from improved recreational fishing would be minor in magnitude, long term, and regional in extent.

**Table 3.14-47. Visitation and Economic Benefits at Blue River, Cougar, Detroit, Fall Creek, Green Peter, Hills Creek, and Lookout Point Under Alternative 3B**

| Dam/Reservoir | Change in Average Annual Visits | Percent Change in Total Annual Benefits | Magnitude of effects |
|---|---|---|---|
| Cougar | -17,000 | -42.38% | Major adverse |
| Green Peter | -93,000 | -55.45% | Major adverse |
| Hills Creek | -10,000 | -26.17% | Major adverse |
| Lookout Point | -7,000 | -8.26% | Moderate adverse |
| Detroit | -8,000 | -4.99% | Minor adverse |
| Blue River | -6,000 | -36.10% | Major adverse |
| Fall Creek | 3,000 | 1.36% | Minor beneficial |

**<u>Riverine Recreation</u>**

As discussed above in Section 3.14.2.3.8 (Deeper fall reservoir drawdowns for downstream fish passage (#40), spring reservoir drawdown for downstream fish passage (#720); and Fall Creek drawdown), drawing down reservoirs would have effects on river flows downstream of WVS reservoirs. Visitation estimates are not made for riverine areas because of the many access points available to recreators. Instead, changes in alternative flows compared to the NAA at eleven gage locations throughout the study area are used as an indicator of general effects to recreation. The magnitude of effects to specific rivers or river reaches are shown below in Table 3.14-48. Higher stream flows would increase riverine recreational carrying capacities and benefit activities such as white-water rafting. Increases in water flows would benefit fish habitat through water temperature, but could also improve riparian vegetation which would generally improve aesthetics and subsequently benefit the riverine recreational experience.

**Table 3.14-48. Percent Change in Flows and Magnitude of Effects on the Coast Fork Willamette, Long Tom, McKenzie, Middle Fork Willamette, Middle Willamette, North Santiam, South Santiam, and Upper Willamette rivers Under Alternative 3B**

| River Gage | Season | Percent Change in Flows from No Action | Magnitude of effects |
|---|---|---|---|
| **Coast Fork Willamette River** | | | |
| Goshen | Fall/Winter average | -0.67% | Negligible adverse |
| | Spring/Summer average | 1.40% | Minor beneficial |
| **Long Tom River** | | | |
| Monroe | Fall/Winter average | -0.02% | Negligible adverse |
| | Spring/Summer average | 0.14% | Negligible beneficial |
| **McKenzie River** | | | |
| Vida | Fall/Winter average | -2.03% | Minor adverse |
| | Spring/Summer average | -3.06% | Minor adverse |
| **Middle Fork Willamette River** | | | |
| Jasper | Fall/Winter average | -3.57% | Minor adverse |
| | Spring/Summer average | 6.06% | Moderate beneficial |
| **Middle Willamette River** | | | |
| Salem | Fall/Winter average | -2.40% | Minor adverse |
| | Spring/Summer average | -1.24% | Minor adverse |
| **North Santiam River** | | | |
| Jefferson and Mehama average | Fall/Winter average | -2.79% | Minor adverse |
| | Spring/Summer average | 6.93% | Moderate beneficial |
| **South Santiam River** | | | |
| Waterloo | Fall/Winter average | -4.41% | Minor adverse |
| | Spring/Summer average | -5.28% | Moderate adverse |
| **Upper Willamette River** | | | |
| | Fall/Winter average | -2.33% | Minor adverse |

| River Gage | Season | Percent Change in Flows from No Action | Magnitude of effects |
|---|---|---|---|
| Albany, Eugene, and Harrisburg averages | Spring/Summer average | -1.96% | Minor adverse |

#### *3.14.2.9.8 Suite of near-term operations*

The suite of near-term operations would be included in Alternative 3B. As discussed in Section 3.14.2.3.9, effects from the deep drawdowns at Cougar, Green Peter, Lookout Point, and Fall Creek, and the delayed refills at Fall Creek and Cougar (which would lengthen the effects of the deep drawdowns) would be major, adverse, short term, and recur in the long term. Effects of the delayed refill (with no deep drawdown) at Foster would be moderate, adverse, and recur in the long term. Effects of all other near-term operations would be indirect, beneficial, and minor in the long term. The adverse effects would be local in extent because they would be limited to the dam/reservoir, and beneficial effects would be regional in extent because benefits to recreational fishing would be perceived throughout the WVS.

#### *3.14.2.9.9 Climate Change*

Alternative 3B would improve fish passage by using operations-focused measures (using a deep drawdown to Cougars Dam's DT). As discussed above in Section 3.14.2.4.1, climate change is expected to adversely affect water quantity and air and water quality. The measures in Alternative 3B would improve water quality by normalizing temperatures and provide fish passage with numerous deep drawdowns. Alternatives 3A and 3B would include more than twice as many drawdowns as the other alternatives, and Alternative 3B would include the deeper drawdown to the Cougar DT. Due to the number of deep drawdowns and the deeper drawdown at Cougar, climate change would exacerbate the effects of Alternative 3B more than all other action alternatives. Climate change in combination with the measures under Alternative 3B would have direct, adverse, minor to moderate, regional effects to recreation in the long term.

### ***3.14.2.10 Alternative 4 – Structures-Based Fish Passage Alternative***

Under Alternative 4, adverse effects from augmenting gravel below dams, maintaining or altering revetments, maintaining existing and new fish release sites, restoring upstream and downstream passage at drop structures, and providing Pacific lamprey passage and infrastructure would range from negligible to minor in magnitude; be short term in duration; and local in extent. Adverse effects from operation, maintenance, repair, replacement, and rehabilitation would range from negligible to moderate in magnitude; be short, medium, and long term in duration, and local in extent.

Adverse effects from improving structures to reduce TDG, constructing WTC towers and downstream fish passage infrastructure, the Foster fish ladder temperature improvement, and constructing AFFs would range from negligible to moderate in the medium term and be local in extent. At Foster Dam only, potential adverse effects from constructing downstream fish passage infrastructure would range from negligible to minor in the short term and be local in extent from the fish weir modifications. Adverse effects from adapting the hatchery program would be negligible in magnitude in the long term and regional in extent. Adverse effects from the Fall Creek drawdown would be major, adverse, short term and recur in the long term. The severity of short- and medium-term effects from construction on the quality of recreation (due to increases in noise levels, air emissions, and traffic as well as visual intrusions) would be dependent on the proximity of the recreator or recreational facilities to the project area. The magnitude of effects to specific recreation areas at each dam and reservoir and riverine areas in general due to construction projects are discussed below.

Indirect beneficial effects from augmenting gravel below dams, maintaining or altering revetments, restoring upstream and downstream passage at drop structures, augmenting instream flows using the inactive or power pools, continued operation of AFFs, adapting the hatchery program, improving structures to reduce TDG, constructing WTC towers and downstream fish passage infrastructure, the Foster fish ladder temperature improvement, constructing AFFs, and Fall Creek drawdowns would be minor in magnitude. The effects of these measures would all occur in the long term and be regional in extent. Under Alternative 4, adverse effects would be more severe than Alternatives 1, 2A, 2B and 5, but less severe than Alternatives 3A and 3B due to the number of recurring drawdowns, inclusion of the near-term operations, and number of medium-term construction measures.

###### *3.14.2.10.1 Gravel augmentation below dams (#384), Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), Maintenance of existing and new fish release sites above dams (#726), and Restore upstream and downstream passage at drop structures (#639)*

Under all action alternatives, augmenting gravel below dams would occur below Big Cliff, Blue River, Cougar, and Foster, maintaining or altering revetments would occur basin-wide in rivers, and maintenance of existing and new fish release sites would occur basin-wide. Under Alternative 4 (and Alternative 1), restoring upstream and downstream passage at drop structures would occur at Fern Ridge, but its effects are discussed generally under riverine recreation because recreational facilities at Fern Ridge would be virtually unaffected.

As discussed above in Section 3.14.2.3.1, potential adverse effects would range from negligible to minor in magnitude in the short term, and beneficial effects would be indirect and minor in magnitude in the long term. The short-term effects would be local in extent because they would be limited to the dam/reservoir or river. The long-term effects would be regional in extent because indirect benefits to recreational fishing would be perceived throughout the WVS. The magnitude of effects to specific recreation areas at each dam and reservoir and riverine areas are discussed below.

**Big Cliff Dam and Reservoir**

As discussed above under the other action alternatives, effects would be negligible at Big Cliff Dam and Reservoir because augmenting gravel below dams and maintaining or altering revetments would occur in rivers, and Big Cliff Dam and Reservoir does not have designated recreational facilities within two miles of the river.

**Blue River Dam and Reservoir**

As discussed above under the other action alternatives, the Blue River Dam and Reservoir is adjacent to one viewpoint, which would experience minor effects due to its proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. The viewpoint would also experience moderate effects due to its proximity to the channel modifications required for using the spillway for surface spill. The Mona and Lookout campgrounds would experience negligible effects as these facilities would be over three miles away from construction.

**Cougar Dam and Reservoir**

As discussed above under the other action alternatives, the Cougar Dam is adjacent to two viewpoints, which would experience minor effects due to their proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. Other recreational facilities, such as Echo Park and the Slide Creek and Sunnyside campgrounds, would experience negligible effects as these facilities would be over one or two miles away from construction, respectively. The Delta Campground is approximately two miles downstream of the Cougar Dam and is closed indefinitely due to the Holiday Farm wildfire. Because augmenting gravel would occur on and in the rivers below dams, the Delta Campground would experience minor effects if it reopened and construction work occurred in close proximity.

**Foster Dam and Reservoir**

As discussed above under the other action alternatives, Foster Dam is adjacent to Lakeshore and Andrew S. Wiley parks, and Edgewater Park and Marina; and about a half mile from Shea Point. These facilities would experience minor effects due to their proximity to where gravel would be augmented below the dam and potentially from the maintenance of existing and new fish release sites. Lewis Creek and Sunnyside parks would experience negligible effects as these facilities would be over two miles away from construction.

**Riverine Recreation**

Augmenting gravel below dams, maintaining or altering revetments, and restoring upstream and downstream passage at drop structures would occur in and on rivers, and would affect the experience for recreationists at or near the construction projects. As discussed above under the other action alternatives, potential adverse effects would range from negligible to minor in magnitude in the short term: minor to a recreator passing by the project location, and negligible as the distance from the project location increases. Beneficial effects would be indirect and minor in magnitude in the long term.

### *3.14.2.10.2 Provide Pacific lamprey passage and infrastructure (#52)*

Under Alternative 4, providing Pacific lamprey passage and infrastructure would occur at Fern Ridge and Hills Creek. As discussed above in Section 3.14.2.3.2, potential adverse effects would range from negligible to minor in magnitude in the short term. Effects would be local in extent because they would be limited to the dam/reservoir. The severity of short-term effects on the quality of recreation would depend on the proximity of the recreational facilities to construction. The magnitude of effects to specific recreation areas are discussed below at each dam and reservoir.

**Fern Ridge Dam and Reservoir**

The Fern Ridge Dam is adjacent to Kirk and Orchard Point Parks, which would experience minor effects due to their proximity to where Pacific lamprey passage and infrastructure would be provided. More specifically, increases in noise and visual intrusions would be slightly noticeable to hunters, bird-watchers, and hikers at Kirk Park. Kirk Park is one of 11 management units within the Fern Ridge Wildlife Area, which covers approximately half of the reservoir and consists of wetlands, wet prairie, oak and mixed woodlands, upland prairie, and freshwater aquatic habitats. Effects to sailing (the large surface area and consistent winds make Fern Ridge one of the best sailing reservoirs in Oregon) would not occur; effects would not be visible, audible, or otherwise felt on the reservoir because lamprey passage infrastructure would be provided on the downstream side of the dam. Effects would likely be negligible at other recreational areas like Perkins and Zumwalt parks, which would be over two miles away from construction.

**Hills Creek Dam and Reservoir**

Hills Creek Dam is adjacent to two viewpoints (one on either side of the dam), which would experience minor effects due to their proximity to where Pacific lamprey passage and infrastructure would be provided. This reservoir is a designated stop along the Three Sisters section of the Oregon Cascades Birding Trail, and noise from construction activities could scare birds away and decrease the recreational experience for bird watchers. The 27-mile Middle Fork Willamette Trail also borders the Hills Creek Reservoir, and construction activities could decrease the experience for recreationists such as hikers, horseback riders, and mountain bikers. Other recreational facilities, such as the Packard Creek Campground and Bingham Boat Ramp, would experience negligible effects as these facilities would be over two miles away from construction.

### *3.14.2.10.3 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide.

As discussed above under the other action alternatives, potential adverse effects from scheduled/routine maintenance would be negligible to minor in magnitude in the short and long term. Potential adverse effects from major maintenance and rehabilitation would be negligible to moderate in magnitude in the medium and long term. The short-, medium-, and long-term effects would be local in extent because they would be limited to the dam/reservoir or river.

*3.14.2.10.4 Adapt Hatchery Program (#719)*

Under all action alternatives, adapting the hatchery program would occur at all hatcheries (Marion Forks, South Santiam, Leaburg, McKenzie, and Willamette). As discussed above under the other action alternatives, potential effects would be indirect, adverse, and negligible in the long term. Effects would be regional in extent because indirect effects to recreational fishing would occur throughout the WVS.

*3.14.2.10.5 Structural improvements to reduce total dissolved gas (#174), Construct WTC towers (#105), Construct structural downstream fish passage infrastructure (#392), Foster Fish Ladder Temperature Improvement (#479), and Construct AFFs (#722)*

Under Alternative 4, improving structures to reduce TDG would occur at Cougar, Detroit, Dexter, Foster, Green Peter, and Lookout Point; constructing WTC towers would occur at Detroit, Hills Creek, and Lookout Point; constructing structural downstream fish passage infrastructure would occur at Cougar, Detroit, Foster, Hills Creek, and Lookout Point; the fish ladder temperature improvement would occur at Foster; and constructing an AFF would occur at Hills Creek.

As discussed above in Section 3.14.2.3.7, potential adverse effects would range from negligible to moderate in the medium term. At Foster Dam, potential adverse effects would range from negligible to minor in the short term from the fish weir modifications. Potential beneficial effects would be indirect and minor in magnitude in the long term. The short- and medium-term effects would be local in extent because they would be limited to the dam/reservoir. The long-term effects would be regional because indirect benefits to recreational fishing would be perceived throughout the WVS. The magnitude of effects to specific recreation areas are discussed below at each dam and reservoir.

**Detroit Dam and Reservoir**

The Detroit Dam is adjacent to one viewpoint, which would experience moderate effects due to its proximity to where downstream fish passage and a WTC tower would be constructed. This dam is a designated stop along the Mt. Jefferson section of the Oregon Cascades Birding Trail where visitors can see osprey and neotropical migrant songbirds. Noise from construction activities could scare birds away and decrease the recreational experience for bird watchers. Recreational facilities on Detroit Reservoir, such as the Mongold Day Use Area and Detroit Lake State Park, would experience negligible effects as these facilities would be over two miles away from construction.

**Green Peter Dam and Reservoir**

Green Peter Dam is adjacent to Billings Park and a viewpoint, which would experience moderate effects due to their proximity to where structures would be improved to reduce TDG. Other recreational facilities, such as the Thistle Creek Boat Ramp and Whitcomb Creek Park, would experience negligible effects as these facilities would be over two miles away from construction.

**Dexter and Lookout Point dams and reservoirs**

The Dexter Dam is adjacent to Dexter and Lowell Parks, and the Lookout Point Dam is adjacent to Meridian and Orchard parks, which would experience moderate effects due to their proximity to where a WTC tower would be constructed at Lookout Point and structures would be improved to reduce TDG at Dexter. Dexter is a designated stop along the McKenzie Loop of the Willamette Valley Birding Trail where visitors can see migratory and resident songbirds and osprey and eagles along the northeast shoreline. Noise from construction activities could scare birds away and decrease the recreational experience for bird watchers. Recreational facilities on Lookout Point Reservoir, such as Landax Park and Signal Point Boat Ramp, would experience negligible effects as these facilities would be over two miles away from construction.

**Cougar, Foster, and Hills Creek dams and reservoirs**

As discussed above in Section 3.14.2.3.7, changes in the quality of recreation would increase proportionally with the recreational facility's proximity to where structures would be improved to reduce TDG at Cougar and Foster; downstream fish passage would be constructed at Cougar, Foster, and Hills Creek; WTC towers would be constructed at Hills Creek; the fish ladder temperature improvement would occur at Foster; and an AFF would be constructed at Green Peter. The recreational experience at recreational facilities directly adjacent to Cougar, Foster, and Hills Creek dams would be moderately affected. The specific recreational facilities closest to and farthest from Cougar, Foster, and Hills Creek dams (and therefore the construction sites) are noted above under Sections 3.14.2.10.1 and 3.14.2.10.2.

### *3.14.2.10.6 Fall Creek drawdown*

Under all action alternatives, drawdowns would continue to recur at Fall Creek. As discussed under Section 3.14.2.3.8, effects would be major, adverse, and recur in the long term, and be indirect, beneficial, and minor in the long term.

Potential beneficial effects to visitation under this alternative are shown below in Table 3.14-49. Effects would be minor and beneficial at Fall Creek with approximately 4,000 more annual visitors and a 2 percent increase in total annual benefits. As discussed above in Section 3.14.2.3.8 (Deeper fall reservoir drawdowns for downstream fish passage (#40), spring reservoir drawdown for downstream fish passage (#720); and Fall Creek drawdown), qualitative adverse effects to the recreational experience for those that continue to visit the reservoir during drawdowns would be major. Adverse effects on the recreational experience would be short-term and long-term recurring. Beneficial effects from improved recreational fishing would be indirect, minor in magnitude and long term at Fall Creek. The full list of effects to visitation are available in Appendix K — Recreation Technical Report.

[Note to USACE: Why would Fall Creek experience benefits to visitation during drawdowns under this alternatives and all other action alternatives? Said otherwise, why would there be an increase of 4,000 annual visits and a 1.95 percent increase in annual benefits, corresponding to minor beneficial effects? Drawdowns to all other reservoirs besides Hills Creek would have adverse effects on visitation.]

**Table 3.14-49. Visitation and Economic Benefits at Fall Creek Under Alternative 4**

| Dam/Reservoir | Change in Average Annual Visits | Percent Change in Total Annual Benefits | Magnitude of effects |
|---|---|---|---|
| Fall Creek | 4,000 | 1.95% | Minor beneficial |

**<u>Riverine Recreation</u>**

As discussed above in Section 3.14.2.3.8 (Deeper fall reservoir drawdowns for downstream fish passage (#40), spring reservoir drawdown for downstream fish passage (#720); and Fall Creek drawdown) drawing down reservoirs would have effects on river flows downstream of WVS reservoirs. Visitation estimates are not made for riverine areas because of the many access points available to recreators. Instead, changes in alternative flows compared to the NAA at eleven gage locations throughout the study area are used as an indicator of general effects to recreation (Appendix K — Recreation Technical Report). Higher stream flows would increase riverine recreational carrying capacities and benefit activities such as white-water rafting. Increases in water flows would also benefit fish habitat through water temperature, but could also improve riparian vegetation which would generally improve aesthetics and subsequently benefit the riverine recreational experience. Visitation estimates are not made for riverine areas because of the many access points available to recreators. Instead, changes in alternative flows compared to the NAA at eleven gage locations throughout the study area are used as an indicator of general effects to recreation. The magnitude of effects to specific rivers or river reaches are shown below in Table 3.14-50.

**Table 3.14-50. Percent Change in Flows and Magnitude of Effects on the Coast Fork Willamette, Long Tom, McKenzie, Middle Fork Willamette, Middle Willamette, North Santiam, South Santiam, and Upper Willamette rivers Under Alternative 4**

| River Gage | Season | Percent Change in Flows from No Action | Magnitude of effects |
|---|---|---|---|
| **Coast Fork Willamette River** | | | |
| Goshen | Fall/Winter average | 0.86% | Negligible beneficial |
| | Spring/Summer average | -0.45% | Negligible adverse |
| **Long Tom River** | | | |
| Monroe | Fall/Winter average | -0.02% | Negligible adverse |

| River Gage | Season | Percent Change in Flows from No Action | Magnitude of effects |
|---|---|---|---|
| | Spring/Summer average | 0.14% | Negligible beneficial |
| **McKenzie River** | | | |
| Vida | Fall/Winter average | 1.26% | Minor beneficial |
| | Spring/Summer average | -1.20% | Minor adverse |
| **Middle Fork Willamette River** | | | |
| Jasper | Fall/Winter average | 3.42% | Minor beneficial |
| | Spring/Summer average | -4.97% | Minor adverse |
| **Middle Willamette River** | | | |
| Salem | Fall/Winter average | 0.36% | Negligible beneficial |
| | Spring/Summer average | 0.87% | Negligible beneficial |
| **North Santiam River** | | | |
| Jefferson and Mehama average | Fall/Winter average | -1.07% | Minor adverse |
| | Spring/Summer average | 4.81% | Minor beneficial |
| **South Santiam River** | | | |
| Waterloo | Fall/Winter average | -3.57% | Minor adverse |
| | Spring/Summer average | 11.87% | Moderate beneficial |
| **Upper Willamette River** | | | |
| Albany, Eugene, and Harrisburg averages | Fall/Winter average | 2.11% | Minor beneficial |
| | Spring/Summer average | -2.82% | Minor adverse |

##### *3.14.2.10.7 Suite of near-term operations*

The suite of near-term operations would be included in Alternative 4. As discussed in Section 3.14.2.3.9, effects from the deep drawdowns at Cougar, Lookout Point, and Fall Creek, and the delayed refills at Foster and Cougar would be major, adverse, and recur in the long term, and be indirect, beneficial, and minor in the long term. The effects would be local in extent because they would be limited to the dam/reservoir.

##### *3.14.2.10.8 Climate Change*

Alternative 4 would improve fish passage with structures-based measures. As discussed above in Section 3.14.2.4.1, climate change is expected to adversely affect water quantity and air and water quality. The measures in Alternative 4 would improve water quality by reducing TDG and normalizing temperatures. Alternative 4 would not improve reservoir storage like Alternative 1, but it would feature fewer drawdowns than under all other action alternatives. Therefore, climate change would exacerbate the effects of Alternative 4 more than Alternative 1, but less than Alternatives 2A, 2B, 3A, 3B, and 5. Climate change in combination with the measures under Alternative 4 would have direct, adverse, negligible to minor, regional effects to recreation in the long term.

#### *3.14.2.11 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 5 is similar to Alternative 2B but includes the *refined* integrated habitat and flow regime (#30b), rather than the integrated habitat and flow regime (#30a). This measure would not have adverse effects to the quality of the recreational experience. The inclusion of measure #30b would result in less than 0.5 percent changes in total annual benefits for reservoirs with recurring drawdowns between Alternatives 2B and 5. The full results of visitation estimates are presented in Appendix K — Recreation Technical Report. Therefore, the magnitude of adverse effects of Alternative 5 would be identical to those of Alternative 2B. Due to inclusion of the *refined* integrated habitat and flow regime, indirect benefits to recreation would be greater than Alternative 2B, but not appreciably. Differences in benefits would likely be unnoticeable.

Under Alternative 5, adverse effects from augmenting gravel below dams, maintaining or altering revetments, maintenance of existing and new fish release sites, and providing Pacific lamprey passage and infrastructure would range from negligible to minor in magnitude; be short term in duration; and local in extent. Adverse effects from operation, maintenance, repair, replacement, and rehabilitation would range from negligible to moderate in magnitude; be short, medium, and long term in duration and local in extent. Adverse effects from constructing WTC towers and downstream fish passage infrastructure, the Foster fish ladder temperature improvement, and constructing AFFs would range from negligible to moderate in the medium term and be local in extent. At Foster Dam only, potential adverse effects from constructing downstream fish passage infrastructure would range from negligible to minor in the short term and be local in extent from the fish weir modifications. Adverse effects from adapting the hatchery program would be negligible in magnitude in the long term and regional in extent. Adverse effects from the deeper fall reservoir drawdowns, spring reservoir drawdowns, Fall Creek drawdowns, and suite of near-term operations would be major (moderate at Foster from the near-term operations), adverse, short term, and recur in the long term. The severity of short- and medium-term effects from construction on the quality of recreation (due to increases in noise levels, air emissions, and traffic as well as visual intrusions) would be dependent on the proximity of the recreator or recreational facilities to the project area. The magnitude of effects to specific recreation areas at each dam and reservoir and riverine areas in general due to construction projects are discussed under Alternative 2B.

Indirect beneficial effects from augmenting gravel below dams, maintaining or altering revetments, augmenting instream flows using the inactive and power pools, refined integrated habitat and flow regime, continued operation of AFFs, adapting the hatchery program, constructing WTC towers and downstream fish passage infrastructure, the Foster fish ladder temperature improvement, constructing AFFs, deeper fall reservoir drawdowns, spring reservoir drawdowns, Fall Creek drawdowns, and suite of near-term operations would be minor in magnitude. The effects of these measures would all occur in the long term and be regional in extent.

Under Alternative 5, adverse effects would be the same as Alternative 2B, more severe than Alternatives 1, and 2A, but less severe than Alternatives 3A, 3B, or 4 due to the number of recurring drawdowns. Alternative 5's climate resilience would be the same as Alternative 2B.

##### *3.14.2.11.1 Climate Change*

Alternative 5 is essentially the same as 2B. As discussed above in Section 3.14.2.4.1, climate change is expected to adversely affect water quantity and air and water quality. The measures in Alternative 5 would improve water quality by reducing TDG and normalizing temperatures. It would also provide fish passage. However, it would not improve reservoir storage like Alternative 1. Due to one more deep drawdown than Alternative 2A, climate change would exacerbate the effects of Alternative 5 more than Alternatives 1 or 2A. But overall, the effects would be the same as under Alternative 2A and 2B; climate change in combination with the measures under Alternative 5 would have direct, adverse, minor to moderate, regional effects to recreation in the long term.

#### ***3.14.2.12 Conclusion***

The action alternatives in order of least to most severe adverse effects to recreation would be: 1, 2A, 2B/5, 4, 3A, and 3B.

Severity of adverse effects to recreation is primarily driven by the number of recurring drawdowns that would occur under each measure, and secondarily, by the number of construction projects, particularly those that are medium-term and of moderate magnitude. All recurring drawdowns would have short and long term, major, adverse effects from the visual impacts to both water- and land-based recreationists. Further, recurring drawdowns would make boat ramps unusable sooner in the season for launching motorized boats, and depending on whether drawdowns began in the fall or spring, would shorten the overall recreational season. The near-term operations include recurring drawdowns and delayed refills, which would lengthen the effects of the drawdowns.

Alternative 1 would be the least severe because it would include only one recurring drawdown and would not include the suite of near-term operations. Alternative 1 is the only action alternative that would result in direct benefits to recreation by promoting reservoir storage (i.e., from reducing minimum flows to congressionally authorized minimum flows). All other alternatives would only result in indirect benefits to recreation over time by improving recreational fishing. Alternative 2A would be more severe than Alternative 1, followed by Alternative 2B/5, due to the number of recurring drawdowns. While Alternative 4 would only include one recurring drawdown (like Alternative 1), it contains the most medium-term construction projects. Alternative 3A and 3B would be the most severe, but Alternative 3B would be slightly more severe than Alternative 3A due to the construction of the tower and bridge in order to draw-down Cougar Reservoir to the DT.

## 3.15 LAND USE

The area of analysis for land use is the entire Willamette River Basin (WRB) including all 12 of its sub-basins, even those that do not include a USACE dam. This section uses land *cover* as a surrogate for land *use* due to the large area of analysis and the availability of land cover data via National Land Cover Database (NLCD) satellite imagery. This section provides an overview of land use planning and land use in the WRB; a basin-wide comparison of land use in the 1970s and today; a summary of planned, current, and future development; and an overview of current land use by sub-basin.

Oregon's Department of Land Conservation and Development (DLCD) established a statewide land use planning program to conserve important natural resources; encourage efficient development; coordinate planning activities between governments; enhance the state's economy; and reduce public costs from poorly planned development (OSOS No Date). The statewide land use planning program protects land for farming, forestry, and wildlife habitat while discouraging development outside of urban growth boundaries, lines drawn on planning maps that limit further development. Oregon's land use planning is achieved through a set of 19 goals that include topics such as urbanization, recreational needs, natural resources, and agricultural lands. The statewide goals are implemented through local comprehensive planning; each city and county are required to have comprehensive plans consistent with the statewide goals (DLCD No Date).

The total land area of the WRB is approximately 11,200 square miles, or 7.2 million acres, making it Oregon's largest river basin. Developed land covers approximately 9 percent of the basin, primarily along the Interstate 5 (I-5) corridor, which runs north-south through the western third of the basin and roughly parallel to the Willamette River. A majority of the 3 million residents of the basin inhabit the cities of Portland, Salem, Corvallis, and Eugene along this corridor (NLCD 2019). Forest and agriculture are the most extensive land covers, making up roughly 59 percent and 21 percent of the basin, respectively (NLCD 2019). The WRB is considered the most agriculturally diverse region in Oregon with over 170 varieties of crops and livestock grown in the area. The most abundant crops are hay and pasture, tree fruits and nuts, berries including wine grapes, and an assortment of traditional vegetables such as beets and broccoli (ODA 2020).

### 3.15.1 Basin-wide Land Cover

In the 1930s, WRB prairies began to be converted to agriculture for growing forage and seed crops, mainly common rye grass (Robbins 2021). By the 1970s, approximately 22 percent of the basin had been converted to agriculture, with the remaining cover consisting of forest (70 percent), urban (5 percent), and other uses (3 percent). At this time, the most extensive crop coverages were grass seed (34 percent), wheat (20 percent), and other hay (18 percent), which were primarily grown in areas along the main stem Willamette River in the southern portion of the basin, or dispersed throughout the northern valley (Wentz et al., 1998).

Table 3.15-1 compares basin-wide land cover from the 1970s and 2019. Since the 1970s, developed land has increased by 50 percent, though this still accounts for less than 10 percent of the total land cover in the basin. About 11 percent of previously forested land in the WRB has been logged or burned by wildfires and replaced with shrub/scrub, grassland/herbaceous, and other land cover, though forest cover still accounts for over half of the basin (OFRI, 2014; Oregon Wild; 2019; NLCD, 2019). Agricultural cover has remained fairly constant at about 20 percent of the basin. Note that land cover classified as “other“ includes open water, barren land, woody wetlands, and emergent herbaceous wetlands. Developed - open space, - low intensity, and - high intensity were summed in order to achieve a single number for developed land cover. Deciduous, Evergreen, and mixed forests were summed to achieve a single number for forest land cover.

**Table 3.15-1. Willamette River Basin Land Cover**

| Coverage Type | 1970s | 2019 |
|---|---|---|
| Forest | 70% | 59% |
| Agriculture | 22% | 21% |
| Developed | 6% | 9% |
| Other | 2% | 11% |

Source: Wentz et al. 1998; NLCD 2019

### 3.15.2 Basin-wide Future Urban Development

Oregon’s statewide land use planning program minimizes urban sprawl by discouraging development outside of urban growth boundaries. Table 3.15-2 indicates that, according to 2017 zoning and urban growth boundary data, approximately 94 percent of Oregon’s planned urban space has already been developed, leaving 15,409 acres left for future development[52].

**Table 3.15-2. Willamette River Basin Planned, Current[53], and Future Development**

| Category | Area (acres) |
|---|---|
| Urban Growth Boundary[54] | 473,941 |
| Total Current Urban Development[2, 55, 5] | 445,548 |
| Future Urban Development [3, 4, 56] | 15,409 |

Source: DLCD 2017

[52] The availability of more detailed future land use information is limited by the workload required to analyze each municipality’s comprehensive plan for land use plans, goals, and zoning ordinances, which was deemed unnecessary for a programmatic O&M EIS.
[53] 2017 data was the most recent available data for both urban growth boundaries and zoning.
[54] Area calculated from the 2017 Oregon Department of Land Conservation and Development Urban Growth Boundaries GIS dataset.
[55] Includes Urban Residential, Urban Industrial, Urban Commercial, Mixed-Used Commercial and Residential, Public and Semi-Public Spaces, and Open Spaces.
[56] Area calculated from the 2017 Oregon Department of Land Conservation and Development Zoning GIS dataset.

### 3.15.3 Sub-basin Land Cover

This section describes current (2019) land cover in the WRB distinguished by sub-basin. Table 3.15-3 presents percentages of the dominant land cover types followed by discussion of each.

**Table 3.15-3. Willamette River Sub-Basin Land Cover**

| Basin/Sub-Basin[1] | Forest | Agriculture | Developed | Other[2] |
|---|---|---|---|---|
| WRB | 59% | 21% | 9% | 11% |
| Clackamas | 82% | 7% | 5% | 7% |
| Coast Fork Willamette | 74% | 9% | 4% | 14% |
| Lower Willamette[3] | 28% | 11% | 46% | 14% |
| McKenzie | 81% | 2% | 2% | 15% |
| Middle Fork Willamette | 87% | 2% | 1% | 10% |
| Middle Willamette[4] | 17% | 55% | 21% | 8% |
| Molalla-Pudding | 44% | 37% | 8% | 11% |
| North Santiam | 74% | 10% | 3% | 14% |
| South Santiam | 70% | 14% | 2% | 13% |
| Tualatin[5] | 39% | 27% | 24% | 9% |
| Upper Willamette | 38% | 41% | 11% | 11% |
| Yamhill | 46% | 36% | 7% | 10% |

[1] Note that subbasins may not total to 100% as values have been rounded to the nearest percent.

[2] Land cover classified as ‘other’ includes but is not limited to shrub/scrub, grassland/herbaceous, and wetland.

[3]Contains the majority of the Portland Metropolitan Area.

[4]Contains the Salem Metropolitan Area.

[5]Contains the other notable portion of the Portland Metropolitan Area, which includes the cities of Beaverton and Hillsboro.

Source: NLCD, 2019

Forest is the dominant land cover in the WRB; half of the sub-basins have 70 percent or greater forest cover and only one sub-basin has less than 25 percent forest cover. Forest cover is greatest in the eastern two-thirds of the WRB and along its western fringe. The Willamette River and I-5 corridor in the western third of the basin exhibits relatively less forest cover, as agriculture, urban development, and other uses are more evident in this part of the basin. The Middle Fork and Coast Fork Willamette, North Santiam, Clackamas, and McKenzie sub-basins have the largest amounts of forest coverage (74-87 percent), the least amount of agriculture (2-10 percent), and the least amount of developed land (1-5 percent).

Agricultural land cover is highest in the Middle Willamette sub-basin at 55 percent, followed by the Upper Willamette with 41 percent and the Molalla-Pudding with 37 percent. The Middle Willamette has a wide variety of crops such as grass seed, small grains, fruits and nuts, broccoli, and wine grapes (ODA 2020) and is also the least forested, at only 17 percent coverage.

Development is greatest in the Lower Willamette sub basin at 46 percent, followed by the Tualatin at 24 percent and the Middle Willamette at 21 percent. The Lower Willamette contains Oregon's largest city, Portland, while the Middle Willamette and Tualatin sub-basins are home to Oregon's capital, Salem, and the cities of Beaverton and Hillsboro.

Other land cover is primarily a combination of shrub/scrub, grassland/herbaceous, and wetland, which individually are typically responsible for <1- 8 percent coverage. Land cover categories within 'other' that are generally <1 percent include barren land, open water, and perennial ice/snow. Sub-basins with the largest amounts of 'other' land cover include North and South Santiam, Coast Fork Willamette, Lower Willamette, and McKenzie, with a range of other land cover from 13-15 percent, dominated by shrub/scrub and grassland/herbaceous cover (NLCD 2019).

### 3.15.4 Environmental Effects

This section discusses the potential effects of the Proposed Action and alternatives on land use. The discussion includes the methodology used to assess effects, the measures within the action alternatives that were analyzed, a summary of the effects, and a detailed analysis of effects under each alternative.

#### *3.15.4.1 Methodology*

As discussed in Section 3.15.1, this section uses land *cover* as a surrogate for land *use* due to the large areal extent of the area of analysis (the entire WRB) and the availability of land cover data via National Land Cover Database (NLCD) satellite imagery. The potential effects to land use were assessed by first evaluating which measures could result in changes to land cover. Then, the magnitude, duration, and extent of effects were qualitatively determined using information about each measure from USACE by considering how noticeable land cover changes could be to the public (i.e., in terms of areal extent or general appearance) or how theoretically detectable changes would be at the resolution used by the NLCD. The NLCD uses a 30-meter resolution (i.e., each satellite-image pixel represents an approximately 30-by-30-meter square on the earth's surface). Changes to land cover from each measure would likely be substantially less than 1 percent of the entire WRB, and in some cases, not even detectable at the resolution used by the NLCD. Therefore, the PDT determined that a qualitative analysis would be appropriate for the PEIS.

Although land *use* (the *classification* of how an area is used) changes were not analyzed at the programmatic level, land cover changes could alter the way the public perceives or uses an area. Note that, effects to land *use* are still a possibility from the proposed action and alternatives; however, these effects would be incorporated by future NEPA documents such as master plans. Due to the subjective nature of categorizing changes to land cover as "adverse" or "beneficial", effects are instead discussed generally as changes.

**All comparisons of effects for each action alternative are in comparison to the NAA unless stated otherwise.**

Table 3.15-4 lists the evaluation criteria for the magnitude, duration, and extent and provides a definition for each factor.

**Table 3.15-4. Evaluation Criteria for Potential Effects to Land Use**

| Term | Definition |
|---|---|
| **Magnitude** | |
| Negligible | Changes in land cover would not be noticeable or be barely noticeable in terms of areal extent or general appearance. Changes would not be detectable at the resolution used by the NLCD. |
| Minor | Changes to land cover would be noticeable but small in terms of areal extent or general appearance. Changes would be detectable at the resolution used by the NLCD, but would be very small on a basin-wide scale. |
| Moderate | Changes to land cover would be very noticeable in terms of areal extent or general appearance. Changes would be detectable at the resolution used by the NLCD, but relatively small on a basin-wide scale. |
| Major | Changes to land cover would be highly conspicuous in terms of areal extent or general appearance. Changes would be detectable at the resolution used by the NLCD and notable on a basin-wide scale. |
| **Duration** | |
| Short term | Alteration lasts for the duration of small construction projects, and is continuous for less than 2 years. |
| Medium term | Alteration is limited to the duration of large construction projects, and is continuous for a period of 2-5 years. |
| Long term | Alteration is permanent or lasts continuously beyond operation changes or the completion of all construction projects; the alteration recurs at regular intervals (i.e., deep drawdowns that occur for a 3-week period in the fall and/or spring); or the alteration occurs intermittently. |
| **Extent** | |
| Small | Effects would be confined to the project area. |
| Medium | Effects would be perceived throughout a single county, multiple counties, or the entire WVS. |
| Large | Effects would be perceived throughout the entire state. |

### *3.15.4.2 Measures Analyzed for Land Use*

Measures that could affect land cover are: Construct adult fish facilities (#722), deeper fall reservoir drawdowns for fish passage (#40), spring reservoir drawdown for downstream fish passage (#720), maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), and restore upstream and downstream passage at drop structures (#639). The following measures would have no effect on land cover and are therefore not discussed further.

- Adapt hatchery program (#719)
- Gravel augmentation below dams (#384)
- Construct structural downstream fish passage (#392)
- Construct water temperature control tower (#105)
- Foster fish ladder temperature improvement (#479)
- Structural improvements to reduce total dissolved gas (#174)
- Maintenance of existing and new fish release sites above dams (#726)
- Provide Pacific lamprey passage and infrastructure (#52)
- Reduce minimum flows to Congressionally authorized minimum flow requirements (#723)
- Integrated temperature and habitat flow regime (#30a)
- Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166)
- Use spillway for surface spill in summer (#721)
- Pass water over spillway in spring for fish passage (#714)
- Augment instream flows by using the inactive pool (#718)
- Augment instream flows by using the power pool (#304)
- Operation, Maintenance, Repair, Replacement and Rehabilitation
- Continued Operation of Existing Adult Fish Facilities

A summary of the effects to land use discussed in the following sections is provided in Table 3.15-5. Note that where a range of potential effects would occur, the most severe magnitude of effects for each alternative was listed in this table. For example, if there is a range of minor to moderate effects, moderate effects are included in the table Said otherwise, the most conservative conclusions of potential effects are presented in the table below. Discussion of all effects are included in the discussion below.

**Table 3.15-5. Summary of Effects to Land Use**

| Effect Factor | Alternative | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **NAA** | **1** | **2A** | **2B** | **3A** | **3B** | **4** | **5** |
| **Short-Term** | | | | | | | | |
| Magnitude | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate |
| Extent | Local (FCR) | Local (FCR) | Local (FCR, GPR) | Local (CGR, FCR, GPR) | Local (BLU, CGR, DET, GPR, FCR, HCR, LOP) | Local (BLU, CGR, DET, GPR, FCR, HCR, LOP) | Local (FCR) | Local (CGR, FCR, GPR) |
| **Medium-Term** | | | | | | | | |
| Magnitude | None | None | None | None | None | None | None | None |
| Extent | None | None | None | None | None | None | None | None |
| **Long-Term (Permanent, Intermittent, and/or Recurring)** | | | | | | | | |
| Magnitude | Major | Major | Major | Major | Major | Major | Major; | Major |
| Extent | Local (FCR); regional (basin-wide) | Local (FCR, GPR); regional (FRN, basin-wide) | Local (FCR, CGR, GPR, LOP); regional (basin-wide) | Local (FCR, CGR, GPR, LOP); regional (basin-wide) | Local (BLU, GPR, HCR, CGR, DET, HCR, LOP, FCR); regional (basin-wide) | Local (BLU, GPR, HCR, CGR, DET, HCR, LOP, FCR); regional (basin-wide) | Local (FCR, HCR); regional (FRN, basin-wide) | Local (FCR, CGR, GPR, LOP); regional (basin-wide) |
| Duration Type | Permanent; Recurring | Permanent; Recurring | Permanent; Recurring | Permanent; Recurring | Permanent; Recurring | Permanent; Recurring | Permanent; Recurring | Permanent; Recurring |

### *3.15.4.3 Discussion of Effects by Measures*

This section applies the methodology described above to each measure analyzed for the resource to determine the potential effects. The discussion is grouped by measures that would have similar effects where possible. Construct adult fish facilities (#722), deeper fall reservoir drawdowns for fish passage (#40), spring reservoir drawdown for downstream fish passage (#720), maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), and restore upstream and downstream passage at drop structures (#639) would require construction as described in Section 3.1.2.1. The Draft PEIS discusses general, qualitative effects from construction at the programmatic level. Site-specific project details for each construction measure will be determined during the implementation phase. Subsequent tiered NEPA documents will discuss detailed site-specific effects during the implementation phase. As stated above in Section 3.15.4.1, effects to land *use* are still a possibility from the proposed action and alternatives; however, these effects would be incorporated by future NEPA documents such as master plans.

#### *3.15.4.3.1 Restore Upstream and Downstream Passage at Drop Structures (#639)*

The effects of restoring upstream and downstream passage at drop structures would be minor in magnitude, local in extent, and long term in duration.

Drop structures are small dams built within the river to passively reduce the velocity of water, and can be found at several locations below Fern Ridge. The design of the restoration could include the construction of fish ladders, direct modifications to drop structures, bypass channels, or the replacement of drop structures with riffle and pool systems. Construction of fish ladders, bypass channels, or small modifications to the drop structures without removing the drop structures or changing water levels would have no effect on land cover. However, if the drop structures were removed and replaced with, for example, riffle and pool systems to provide fish passage, land cover would change along a several-mile stretch of the Long Tom River near the project due to the release of impounded water. Open water cover above the drop structures would become noticeably barren and could become vegetated with shrub/scrub cover over time. River banks below the drop structures that had barren or mildly vegetated shrub/scrub cover would be replaced with open water cover. Land cover changes above and below the drop structures would be locally noticeable in terms of general appearance. If changes were detectable at the resolution used by the NLCD, the differences in land cover would be very small on a basin-wide scale. Therefore, the effects would be minor in magnitude and local in extent. These effects would be long term because the land cover changes would last for the life of the project. This measure would be considered an ecological restoration.

#### *3.15.4.3.2 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)*

The effects of maintaining or altering revetments would be minor in magnitude, regional in extent, and long term.

Maintaining revetments could involve using a hydraulic excavator to recondition the revetment with natural materials and would have no effect on land cover. However, if revetments were altered for aquatic ecosystem restoration, previously barren land cover (revetments are often constructed of concrete, large rocks, or other hard materials) would be replaced with vegetative shrub/scrub cover to benefit aquatic ecosystems. Changes to land cover would be locally noticeable in terms of general appearance, but would likely not be detectable at the resolution used by the NLCD because revetments were not clearly shown in 2019 NLCD data. If revetment alterations were detectable at the resolution used by the NLCD, changes would be very small on a basin-wide scale. Although not all revetments would be altered, revetments are found basin-wide and changes to land cover would be locally noticeable at each project area. Alterations would be designed to last for the life of the project; therefore, effects would be regional in extent and long term.

###### *3.15.4.3.3 Construct Adult Fish Facilities (#722)*

The effects of constructing AFFs would be minor in magnitude, local in extent, and long term.

AFF footprints vary depending on a variety of factors, such as the location, estimated throughput, and the method of fish collection. Facilities could require space for parking lots for workers, fish ladders, holding pools, and covered buildings where facilities are monitored. Developed areas associated with AFFs in the WVS range from approximately half of an acre at the Cougar Dam to just under three acres at the Foster Dam, so constructing AFFs could develop up to three acres of land per location. Constructing AFFs would be locally noticeable in terms of both areal extent and general appearance. The developed land would be detectable at the resolution used by the NLCD; however, changes in land cover would be very small on a basin-wide scale. Therefore, effects would be minor in magnitude. Land cover changes would be confined to the project area, so effects would be local in extent. The AFFs would be designed for the life of the project, so the effects would be long term.

###### *3.15.4.3.4 Deeper Fall Reservoir Drawdown for Fish Passage (#40); Drawdown Reservoir in the Spring for Fish Passage (#720); Fall Creek drawdown; Suite of near-term operations*

The effects of drawing-down reservoirs in the fall and spring for fish passage and the suite of near-term operations would be moderate in magnitude, local in extent, and occur in the short term but recur in the long term.

Reservoir drawdowns would result in recurring open-water-to-barren land cover changes. Although land *use* (the *classification* of how an area is used) changes were not analyzed at the programmatic level, recurring drawdowns would substantially alter the way the public uses the area, be very locally noticeable in terms of areal extent and general appearance, and would be detectable at the resolution used by the NLCD. Effects to land *use* are a possibility from the proposed action and alternatives; however, these effects would be incorporated in future NEPA documents. For example, deep drawdowns could lead to OPRD terminating park leases, and USACE would change land classification(s) within the master plan and analyze these effects in the associated NEPA document accordingly; but it is also possible that some boat ramps could eventually be extended in order to mitigate the effects of drawdowns at affected parks. More information about how public use of reservoirs would change due to drawdowns can be found in the Recreation resource under Section 3.14.2.3.8.

The recurring changes would be relatively small on a basin-wide scale. The suite of near-term operations also includes deep drawdowns at Cougar, Green Peter, Lookout Point, and Fall Creek, and delayed refills at Fall Creek and Cougar (which would lengthen the effects of deep drawdowns). Effects on land cover from of each drawdown would be local at a single reservoir and recur annually between approximately three weeks and four months throughout the life of the project, so effects would be local in extent and occur in the short term but recur in the long term.

### *3.15.4.4 No Action Alternative*

Under the NAA, the existing O&M of the WVS would continue. The NAA includes water quality, flow, downstream passage, and upstream passage operations. Because the WVS has been fully constructed and operating for over 50 years, its continued O&M would have no additional effects on land use. The only action in the NAA that would contribute to effects from land cover is the Fall Creek drawdown, which recurs annually to pass fish through the lowest outlet. As discussed above in Section 3.15.4.3.4, the recurring open-water-to-barren land cover changes would be very noticeable on a local level and would be detectable at the resolution used by the NLCD (although still relatively small on a basin-wide scale). Therefore, effects would be moderate in magnitude. The effects on land cover would be confined to the project area; thus, local in extent. The drawdowns would last for approximately three weeks per year but recur for the life of the project, so effects would be short term but recur in the long term.

#### *3.15.4.4.1 Climate Change*

As discussed in Appendix F, climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB, independent of the WVS O&M, over the next 30 years. These factors would contribute to changes in basin-wide land cover; however, they may also result in changes to land use.

Wetter winters and drier summers would be expected to lead to changes in vegetation community composition and distribution over time, as drought tolerant species become predominant and invasive plants potentially take-over communities of native species, as discussed in Section 3.06, Vegetation. Effects to land cover would occur as droughts become more frequent and severe and average summer river flows and reservoir water levels decrease. Some areas of vegetative cover could eventually transition to land cover types such as barren due to the decreasing availability of water and increasing air and water temperatures. Effects from droughts would become more severe over time. While average summer river flows and reservoir water levels would decrease, high rainfall events would become more intense and unpredictable. High rainfall events could lead to severe flooding in some areas, primarily along the mainstem Willamette River, where the WVS project dams cannot provide FRM for immediately adjacent runoff areas. Flooding would temporarily turn the coverage of affected areas into open water, but could have longer-term effects on vegetation. Flooding could destroy vegetation and even buildings in some areas and make them barren, but over time, vegetation would re-establish itself, and buildings (especially near urban areas) could be rebuilt. More severe and noticeable effects to land cover from climate change would occur as the intensity and frequency of wildfires increase. Wildfires would turn forest coverage into barren or shrub/scrub coverages immediately after a fire, and post-wildfire land cover may last for years because it could take areas decades to fully recover from wildfires, depending on the size of the fire. The effects on land cover from wildfires would be more severe than those from recurring drawdowns because they could be notable on a basin-wide scale.

Wildfires and floods in particular would also result in changes to land use (classifications). High rainfall events, especially after a wildfire, can also result in landslides. These natural disasters destroy communities and result in land use changes through expanding development (from housing relocation) and may include rerouting roads and making changes to county or local land use plans as applicable. Floodplains may be re-mapped in order to restrict development. Therefore, the effects of climate change on land cover and land use would be major in magnitude, statewide in extent, and long term.

#### *3.15.4.5 Alternative 1 – Storage-Based Fish Passage*

Under Alternative 1, effects from restoring upstream and downstream passage at drop structures would occur at Fern Ridge and be minor in magnitude, local in extent, and long term in duration. Effects from maintaining revetments using nature-based engineering methods would occur basin-wide and be minor in magnitude, regional in extent, and long term. Effects from constructing an AFF would occur at Green Peter and be minor in magnitude, local in extent, and long term. Effects from continuing the Fall Creek drawdown would be identical to those discussed under the NAA: moderate in magnitude, local in extent, and occur in the short term but recur in the long term.

Effects under Alternative 1 would be less than under all other action alternatives because it would have the fewest recurring drawdowns and does not include the suite of near-term operations. The effects of ecological restorations would be the same as under Alternative 4 but less than under Alternatives 2A, 2B, 3A, 2B, and 5 due to restoring upstream and downstream passage at drop structures.

##### *3.15.4.5.1 Restore Upstream and Downstream Passage at Drop Structures (#639)*

Under Alternative 1, restoring upstream and downstream passage at drop structures would occur at Fern Ridge. As discussed above in Section 3.15.4.3.1, the potential effects would be minor in magnitude, local in extent, and long term in duration.

##### *3.15.4.5.2 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)*

Under all action alternatives, maintaining revetments using nature-based engineering methods would occur basin-wide. As discussed above in Section 3.15.4.3.2, the potential effects would be minor in magnitude, regional in extent, and long term.

##### *3.15.4.5.3 Construct Adult Fish Facilities (#722)*

Under Alternative 1, constructing an AFF would occur at Green Peter. As discussed above in Section 3.15.4.3.3, the potential effects would be minor in magnitude, local in extent, and long term.

##### *3.15.4.5.4 Fall Creek drawdown*

Under all action alternatives, the Fall Creek Reservoir drawdown would continue. As discussed above in Section 3.15.4.3.4, potential effects would be moderate in magnitude, local in extent, and occur in the short term but recur in the long term.

##### *3.15.4.5.5 Climate Change*

Alternative 1 would combine storage-focused measures in order to improve fish passage. These measures would have moderate effects on land cover, but would only result in minor contributions from climate change due to the recurring drawdowns. Alternative 1 would be have the least effects from climate change with respect to land cover than any other action alternative because it includes the fewest recurring drawdowns and is the only alternative that would benefit reservoir storage. As discussed above in Section 3.15.4.4.1, climate change is expected to increase the intensity and severity of wildfires, floods, and landslides independent of the USACE O&M of the WVS. Therefore, the effects from climate change under Alternative 1 (and all alternatives) would be major in magnitude, statewide in extent, and long term.

#### ***3.15.4.6 Alternative 2A – Integrated Water Management Flexibility and ESA Listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam)***

Under Alternative 2A, effects from maintaining revetments using nature-based engineering methods would occur basin-wide and be minor in magnitude, regional in extent, and long term. Effects from constructing an AFF would occur at Green Peter and be minor in magnitude, local in extent, and long term. Effects from the deeper fall reservoir drawdowns at Green Peter, continuing the Fall Creek drawdown, and the suite of near-term operations would occur at Cougar, Green Peter, Lookout Point, and Fall Creek would be similar to those discussed under the NAA: moderate in magnitude, local in extent, and occur in the short term but recur in the long term.

Effects under Alternative 2A would be greater than under Alternatives 1 and 4, but less than under Alternatives 2B, 3A, 3B, and 5. The effects of ecological restorations would be less than under Alternatives 1 and 4 and the same as under all other action alternatives due to restoring or altering revetments.

##### *3.15.4.6.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)*

Under all action alternatives, maintaining revetments using nature-based engineering methods would occur basin-wide. As discussed above in Section 3.15.4.3.2, the potential effects would be minor in magnitude, regional in extent, and long term.

##### *3.15.4.6.2 Construct Adult Fish Facilities (#722)*

Under Alternative 2A, constructing an AFF would occur at Green Peter. As discussed above in Section 3.15.4.3.3, the potential effects would be minor in magnitude, local in extent, and long term.

##### *3.15.4.6.3 Deeper Fall Reservoir Drawdown for Fish Passage (#40); Fall Creek drawdown; Suite of near-term operations*

Under all action alternatives, the Fall Creek Reservoir drawdown would continue, and under Alternative 2A, deeper fall reservoir drawdowns would occur at Green Peter and the suite of near-term operations would occur at Cougar, Green Peter, Lookout Point, and Fall Creek. As discussed above in Section 3.15.4.3.4, potential effects would be moderate in magnitude, local in extent, and occur in the short term but recur in the long term.

##### *3.15.4.6.4 Climate Change*

Alternative 2A would integrate water management flexibility and ESA-listed fish measures (using structural downstream passage at Cougar Dam). These measures would have moderate effects on land cover, but would only result in minor contributions from climate change due to the recurring drawdowns. Alternative 2A would have more recurring drawdowns than under Alternatives 1 and 4, but less than under Alternatives 2B, 3A, 3B, and 5. As discussed above in Section 3.15.4.3, the NAA, climate change is expected to increase the intensity and severity of wildfires, floods, and landslides independent of the USACE O&M of the WVS. Therefore, the effects from climate change under Alternative 2A (and all alternatives) would be major in magnitude, statewide in extent, and long term.

#### ***3.15.4.7 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)***

Under Alternative 2B, effects from maintaining revetments using nature-based engineering methods would occur basin-wide and be minor in magnitude, regional in extent, and long term. Effects from constructing an AFF would occur at Green Peter and be minor in magnitude, local in extent, and long term. Effects from the deeper fall reservoir drawdowns at Cougar and Green Peter, spring reservoir drawdowns at Cougar, continuing the Fall Creek drawdown, and the suite of near-term operations would occur at Cougar, Green Peter, Lookout Point, and Fall Creek would be similar to those discussed under the NAA: moderate in magnitude, local in extent, and occur in the short term but recur in the long term.

Effects under Alternative 2B would be greater than under Alternatives 1, 2A, and 4, the same as under Alternative 5, and less than under Alternatives 3A and 3B.

###### *3.15.4.7.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)*

Under all action alternatives, maintaining revetments using nature-based engineering methods would occur basin-wide. As discussed above in Section 3.15.4.3.2, the potential effects would be minor in magnitude, regional in extent, and long term.

###### *3.15.4.7.2 Construct Adult Fish Facilities (#722)*

Under Alternative 2B, constructing an AFF would occur at Green Peter. As discussed above in Section 3.15.4.3.3, the potential effects would be minor in magnitude, local in extent, and long term.

###### *3.15.4.7.3 Deeper Fall Reservoir Drawdown for Fish Passage (#40); Drawdown Reservoir in the Spring for Fish Passage (#720); Fall Creek drawdown; Suite of near-term operations*

Under all action alternatives, the Fall Creek Reservoir drawdown would continue, and under Alternative 2B, deeper fall reservoir drawdowns would occur at Cougar and Green Peter, spring reservoir drawdowns would occur at Cougar, and the suite of near-term operations would occur at Cougar, Green Peter, Lookout Point, and Fall Creek. As discussed above in Section 3.15.4.3.4, potential effects would be moderate in magnitude, local in extent, and occur in the short term but recur in the long term.

###### *3.15.4.7.4 Climate Change*

Alternative 2B would integrate water management flexibility and ESA-listed fish measures (using a deep drawdown to Cougar Dam’s DT). These measures would have moderate effects on land cover, but would only result in minor contributions from climate change due to the recurring drawdowns. Alternative 2B would have more recurring drawdowns than under Alternatives 1, 2A, 4, and 5, but less than under Alternatives 3A and 3B. As discussed above in Section 3.15.4.4.1, climate change is expected to increase the intensity and severity of wildfires, floods, and landslides independent of the USACE O&M of the WVS. Therefore, the effects from climate change under Alternative 2B (and all alternatives) would be major in magnitude, statewide in extent, and long term.

### *3.15.4.8 Alternative 3A – Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)*

Under Alternative 3A, effects from maintaining revetments using nature-based engineering methods would occur basin-wide and be minor in magnitude, regional in extent, and long term. Effects from constructing AFFs would occur at Blue River, Green Peter, and Hills Creek and be minor in magnitude, local in extent, and long term. Effects from the deeper fall reservoir drawdowns at Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point, spring reservoir drawdowns at Cougar, Detroit, and Lookout Point, continuing the Fall Creek drawdown, and the suite of near-term operations at Cougar, Green Peter, Lookout Point, and Fall Creek would be similar to those discussed under the NAA: moderate in magnitude, local in extent, and occur in the short term but recur in the long term.

Effects under Alternative 3A would be the same as under Alternative 3B, which would be more severe than under any other action alternatives due to the number of recurring drawdowns and AFFs. The effects of ecological restorations would be less than under Alternatives 1 and 4 and the same as under all other action alternatives due to restoring or altering revetments.

#### *3.15.4.8.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)*

Under all action alternatives, maintaining revetments using nature-based engineering methods would occur basin-wide. As discussed above in Section 3.15.4.3.2, the potential effects would be minor in magnitude, regional in extent, and long term.

#### *3.15.4.8.2 Construct Adult Fish Facilities (#722)*

Under Alternative 3A, constructing AFFs would occur at Blue River, Green Peter, and Hills Creek. As discussed above in Section 3.15.4.3.3, the potential effects would be minor in magnitude, local in extent, and long term.

#### *3.15.4.8.3 Deeper Fall Reservoir Drawdown for Fish Passage (#40); Drawdown Reservoir in the Spring for Fish Passage (#720); Fall Creek drawdown; Suite of near-term operations*

Under all action alternatives, the Fall Creek Reservoir drawdown would continue, and under Alternative 3A, deeper fall reservoir drawdowns would occur at Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point, spring reservoir drawdowns would occur at Cougar, Detroit, and Lookout Point, and the suite of near-term operations would occur at Cougar, Green Peter, Lookout Point, and Fall Creek. As discussed above in Section 3.15.4.3.4, potential effects would be moderate in magnitude, local in extent, and occur in the short term but recur in the long term.

##### *3.15.4.8.4 Climate Change*

Alternative 3A would improve fish passage by using operations-focused measures (using a deep drawdown to Cougars Dam's RO). These measures would have moderate effects on land cover, but would only result in minor contributions from climate change due to the recurring drawdowns. Alternative 3A would have more recurring drawdowns than under Alternatives 1, 2A, 2B, 4, and 5, but fewer than under Alternative 3B. As discussed above in Section 3.15.4.4.1, climate change is expected to increase the intensity and severity of wildfires, floods, and landslides independent of the USACE O&M of the WVS. Therefore, the effects from climate change under Alternative 3A (and all alternatives) would be major in magnitude, statewide in extent, and long term.

#### ***3.15.4.9 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)***

Under Alternative 3B, effects from maintaining revetments using nature-based engineering methods would occur basin-wide and be minor in magnitude, regional in extent, and long term. Effects from constructing AFFs would occur at Blue River, Green Peter, and Hills Creek and be minor in magnitude, local in extent, and long term. Effects from the deeper fall reservoir drawdowns at Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point, spring reservoir drawdowns at Cougar, Green Peter, and Hills Creek, continuing the Fall Creek drawdown, and the suite of near-term operations would occur at Cougar, Green Peter, Lookout Point, and Fall Creek would be similar to those discussed under the NAA: moderate in magnitude, local in extent, and occur in the short term but recur in the long term.

Effects under Alternative 3B would be the same as under Alternative 3A, which would be more severe than under any other action alternatives due to the number of recurring drawdowns and AFFs.

##### *3.15.4.9.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)*

Under all action alternatives, maintaining revetments using nature-based engineering methods would occur basin-wide. As discussed above in Section 3.15.4.3.2, the potential effects would be minor in magnitude, regional in extent, and long term.

##### *3.15.4.9.2 Construct Adult Fish Facilities (#722)*

Under Alternative 3B, constructing an AFF would occur at Blue River, Green Peter, and Hills Creek. As discussed above in Section 3.15.4.3.3, the potential effects would be minor in magnitude, local in extent, and long term.

##### *3.15.4.9.3 Deeper Fall Reservoir Drawdown for Fish Passage (#40); Drawdown Reservoir in the Spring for Fish Passage (#720); Fall Creek drawdown; Suite of near-term operations*

Under all action alternatives, the Fall Creek Reservoir drawdown would continue, and under Alternative 3B, drawing-down reservoirs in the fall for fish passage would occur at Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point, drawing-down reservoirs in the spring for fish passage would occur at Cougar, Green Peter, and Hills Creek, and the suite of near-term operations would occur at Cougar, Green Peter, Lookout Point, and Fall Creek. As discussed above in Section 3.15.4.3.4, potential effects would be moderate in magnitude, local in extent, and occur in the short term but recur in the long term.

##### *3.15.4.9.4 Climate Change*

Alternative 3B would improve fish passage by using operations-focused measures (using a deep drawdown to Cougars Dam's DT). These measures would have moderate effects on land cover, but would only result in minor contributions from climate change due to the recurring drawdowns. Alternative 3B would have more recurring drawdowns than under any other action alternative; therefore, it would have the most effects from climate change with respect to land cover. As discussed above in Section 3.15.4.4.1, climate change is expected to increase the intensity and severity of wildfires, floods, and landslides independent of the USACE O&M of the WVS. Therefore, the effects from climate change under Alternative 3B (and all alternatives) would be major in magnitude, statewide in extent, and long term.

#### ***3.15.4.10 Alternative 4 – Structures-Based Fish Passage Alternative***

Under Alternative 4, effects from restoring upstream and downstream passage at drop structures would occur at Fern Ridge and be minor in magnitude, local in extent, and long term in duration. Effects from maintaining revetments using nature-based engineering methods would occur basin-wide and be minor in magnitude, regional in extent, and long term. Effects from constructing an AFF would occur at Hills Creek and be minor in magnitude, local in extent, and long term. Effects from continuing the Fall Creek drawdown and the suite of near-term operations at Cougar, Green Peter, Lookout Point, and Fall Creek would be similar to those discussed under the NAA: moderate in magnitude, local in extent, and occur in the short term but recur in the long term.

Effects under Alternative 4 would be greater than under Alternative 1 due to the suite of near-term operations and would be less than under all other action alternatives due to the relatively few recurring drawdowns. The effects of ecological restorations would be the same as under Alternative 1 and greater than under all other action alternatives due to restoring upstream and downstream passage at drop structures.

##### *3.15.4.10.1 Restore Upstream and Downstream Passage at Drop Structures (#639)*

Under Alternative 4, restoring upstream and downstream passage at drop structures would occur at Fern Ridge. As discussed above in Section 3.15.4.3.1, the potential effects would be minor in magnitude, local in extent, and long term in duration.

##### *3.15.4.10.2 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)*

Under all action alternatives, maintaining revetments using nature-based engineering methods would occur basin-wide. As discussed above in Section 3.15.4.3.2, the potential effects would be minor in magnitude, regional in extent, and long term.

##### *3.15.4.10.3 Construct Adult Fish Facilities (#722)*

Under Alternative 4, constructing an AFF would occur at Hills Creek. As discussed above in Section 3.15.4.3.3, the potential effects would be minor in magnitude, local in extent, and long term.

##### *3.15.4.10.4 Fall Creek drawdown; Suite of near-term operations*

Under all action alternatives, the Fall Creek Reservoir drawdown would continue, and the suite of near-term operations would occur at Cougar, Green Peter, Lookout Point, and Fall Creek. As discussed above in Section 3.15.4.3.4, potential effects would be moderate in magnitude, local in extent, and occur in the short term but recur in the long term.

##### *3.15.4.10.5 Climate Change*

Alternative 4 would improve fish passage with structures-based measures. These measures would have moderate effects on land cover, but would only result in minor contributions from climate change due to the recurring drawdowns. Alternative 4 would have fewer recurring drawdowns than Alternatives 2A, 2B, 3A, 3B, and 5, and would have the same number of drawdowns as Alternative 1; however, it would not benefit reservoir storage, so it would have greater effects from climate change with respect to land cover as Alternative 1. As discussed above in Section 3.15.4.4.1, climate change is expected to increase the intensity and severity of wildfires, floods, and landslides independent of the USACE O&M of the WVS. Therefore, the effects from climate change under Alternative 4 (and all alternatives) would be major in magnitude, statewide in extent, and long term.

#### ***3.15.4.11 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)***

Alternative 5 would only differ from Alternative 2B by way of the refined integrated temperature management and habitat flow regime measure (#30b), which would not have effects on land cover. Therefore, the effects of Alternative 5 would be identical to those under

Alternative 2B: effects would be greater than under Alternatives 1, 2A, and 4, and less than under Alternatives 3A, and 3B. Land cover effects from ecological restorations would be less than under Alternatives 1 and 4 and the same as under all other action alternatives due to maintaining or altering revetments.

#### *3.15.4.12 Conclusion*

Severity of effects on land use is primarily driven by the number of recurring drawdowns, and secondarily by the number of construction projects that would require land to be developed (construction of AFFs). The action alternatives organized in order of least to greatest effects on land use would be: 1, 4, 2A, 2B and 5, and 3A and 3B. Land cover effects would also occur from ecological restoration projects, which would be the greatest under Alternatives 1 and 4 (equal) and less than Alternatives 2A, 2B, 3A, 3B, and 5 (equal).

## 3.16 HAZARDOUS MATERIALS

Hazardous materials are defined by the EPA and Occupational Safety and Health Administration (OSHA) as substances that are hazardous to the health of people, plants, or animals. These include materials that are stored and used for O&M activities in the WVS, such as corrosives, flammables, and toxic agents that can cause harm to human health and the environment.

### 3.16.1 Affected Environment

The area of analysis for hazardous materials is the WVS. Hazardous materials are primarily used in the WVS at dams, fish collection and hatchery facilities, and construction sites for O&M activities. This section begins with a discussion of hazard communication and training, and is then organized by hazardous materials and hazardous material-using activities. Hazardous waste is considered in Section 3.24, Public Health – Hazardous, Toxic, and Radioactive Waste.

#### *3.16.1.1 Hazard Communication and Training*

OSHA's 29 CFR 1900.1200 requires workers to be informed of and able to identify hazardous chemicals, as well as protect themselves from hazardous chemical exposures. In order to accomplish this, USACE implements a written Hazard Communication plan that is revised regularly as needed. This plan includes but is not limited to information on: employee training, safety data sheets (SDSs), container labeling, chemical inventory lists, personal protective equipment (PPE) spills, chemicals in pipes, and methods to reduce or prevent exposure. Physical copies of the Hazard Communication Plan are provided at the Cougar, Cottage Grove, Detroit, Dexter, Fern Ridge, Foster, and Lookout Point projects as well as at the pre-work meetings for all contractors. Electronic copies are available on all desktop computers.

Health and safety training occurs to provide employees with proper information before new employees start their initial assignments, and whenever a new chemical is introduced into a work area. This training begins with a general hazard communication training video followed by a quiz. Next, chemical exposure specific to that employee's job is discussed with a supervisor. This includes where the Hazard Communication Plan is stored, hazards associated with chemicals, techniques and observations used to detect the presence or release of a chemical, procedures to prevent exposure, and emergency procedures.

USACE also performs regular personnel training to keep current employees up to date on equipment, procedures, regulations, facility operations, and site-specific protocols as applicable. Annual oil spill training for hydroelectric dam employees is conducted in accordance with 40 CFR 112.7(f). Employees who handle petroleum products are additionally trained in areas of drum handling, petroleum transfers, methods of identifying oil levels on all oil-filled operating equipment, incident command, and the operation of pumps and/or sumps within the Safe Clearance Procedure, USACE's hazardous energy control program. Hazardous energy is defined by OSHA as "any electrical, mechanical, hydraulic, pneumatic, chemical, nuclear, thermal, gravitational, or other energy that can harm personnel", and is typically discussed in the context of lockout/tagout procedures, where dangerous equipment is properly shut off and unable to be started up again prior to the completion of maintenance or repair work. Additionally, designated first responders are trained and authorized to safely respond to a spill emergency and execute the Spill Response Plan.

#### *3.16.1.2 Construction*

Construction activities, such as dam and building maintenance and repairs, as well as the building of new structures, can potentially introduce hazardous materials into the environment without protective measures. Workers, the public, and wildlife might be exposed to this contamination, which could cause a wide range of health issues depending on the contaminant type, concentration, and exposure duration, as well as the receptor's characteristics, such as age.

Accidental releases from construction, typically associated with improper chemical management, are also sources of possible impacts to public health and safety. Spills can cause soil and water contamination and create exposure pathways to workers, the public, and wildlife. The severity of risks and effects from a spill are determined by its composition and quantity. For example, a common material used for construction that could be spilled at a project site is diesel fuel, which is an irritant of the lungs and skin. High levels of diesel exposure can cause nervous system damage or death (HHS 1995). Other common hazardous chemicals around construction sites include aerosols, solvents, and adhesives.

#### *3.16.1.3 Compressed Gases*

Compressed gases are stored and used at dams, fish facilities, and construction sites around the WVS for controlling valves, oxygenating water and anesthetizing fish, and performing repairs and maintenance that require welding, cutting, and brazing. Hazards associated with compressed gases include oxygen displacement, fires, explosions, and toxic gas exposures, as well as the physical hazards associated with high pressure systems (OSHA No Date). Compressed nitrogen is used in transformers and emergency valves, and oxygen and $CO_2$ are used for fish operations. Acetylene, argon mixture, helium mixture, and oxygen are used for welding, cutting, and brazing. USACE mitigates hazards by adhering to the general requirements for compressed gasses in 29 CFR part 1910.101 and the welding, cutting, and brazing requirements found in 29 CFR part 1910.253. Additionally, BMPs are used, which includes securing cylinders and keeping them away from heat sources.

#### *3.16.1.4 Lead-Based Paint and Asbestos-Containing Materials*

Facilities within the WVS were built between 1945 and 1970, and contain some amount of lead-based paint (LBP) and asbestos-containing materials (ACM) from both original construction and O&M activities. More information is known about the extent of ACM in the WVS than LBP due to the cost-effectiveness of testing. In the 1990s, efforts were made to remove ACM throughout the WVS, but some materials remain. Some areas and materials that were reported to still contain ACM during a 2014 survey include components of electrical wiring and electrical control cabinets, glues and sealants, insulation, and gaskets, although more could exist. LBP is assumed to be present on old building and equipment parts that may need to be removed or replaced as part of O&M activities; therefore, all paint is treated as LBP until it can be verified. Before any materials are removed as part of operations and maintenance, suspected areas would be tested for asbestos. Any ACM identified would be removed and collected by a contractor who follows all OSHA regulations when working with asbestos, and ensures waste is disposed of at an approved facility that follows all applicable environmental laws and regulations.

Although an inconclusive survey for LBP has occurred, LBP is expected on old parts being removed or replaced as part of regular O&M. Before any paint is removed, paint is first tested with lead check swabs. Any contractors removing paint must treat the paint as if it is lead containing, and use an LBP stabilizer to reduce hazardous waste generation. After removal, the debris is tested using the EPA's Toxicity Characteristic Leachate Procedure to determine its waste status. BMPs are also used where applicable, which include paint removal gels or the use of hooded needle guns that mechanically remove and vacuum up paint residue. All wastes would be removed, handled, and disposed of by complying with applicable OSHA and environmental laws and regulations.

#### *3.16.1.5 Underground Storage Tanks*

Only one underground storage tank (UST) exists in the WVS. This UST is located at the Cougar Dam and formerly stored heating oil, but was closed in place in 2008. This UST is scheduled to be removed during a building demolition scheduled for 2024.

#### *3.16.1.6 Oil Spills and Above-ground Storage Tanks*

Oil spills are a public health, safety, and environmental concern at dams, especially the eight USACE dams in the WVS that produce hydropower. Dams rely on a variety of oil-filled equipment to operate. The area that has the highest risk for large spills is the powerhouse, as it typically contains large oil and fuel-filled equipment such as transformers, turbines, generators, and their above-ground storage tanks. Smaller equipment and containers of oil less than 55 gallons are also common around the powerhouse. Each USACE project dam within the WVS has an associated spill prevention, control, and countermeasure (SPCC) plan that details sources, types, volumes, locations, and spill prevention systems and responses specific for that location.

Powerhouse transformers and their oil storage tanks typically contain the largest volumes of oil on site, upwards of several thousand gallons in some cases (Figure 3.16-1). All oil-containing equipment and storage containers in the powerhouse are regularly maintained and inspected in accordance with the preventative maintenance schedule established for each piece of equipment. Operational procedures are also in place to minimize spills related to human error and equipment failure. Additionally, oil-filled equipment and storage containers are constructed of steel and stored at ambient temperature and pressure, which is compatible with petroleum products, thereby minimizing the potential of a release.

Above-ground oil storage tanks and equipment located in or around the powerhouses generally have multiple levels of containment. Drain covers and plugs have been placed near all floor drains in the vicinity of oil reservoirs at the powerhouses, which can be deployed in the event of a spill to allow rooms with oil-containing equipment and storage containers to act as secondary containment. Smaller containers of oil such as drums are stored over mobile pallets capable of containing minor spills.

**Figure 3.16-1.Primary transformer insulating oil being stored in the oil treatment and storage room of the Detroit Dam powerhouse**

Powerhouse combined dewatering and drainage sumps are another possible source of oil releases. All drains adjacent to oil-filled equipment in the powerhouse lead to the sump, which is automatically pumped to an oil-water separator (OWS) and out to the river below the dam by a floating pump activation mechanism. Because powerhouse drainage water is inherently oily, while dewatering water is generally clean, the Project Delivery Team has recommended separating these two sources: discharging clean water beneath the dam and oily water to the currently existing OWS equipment that treats transformer and sump drainages. Currently, Foster and Green Peter are the only dams out of the eight that produce power that do not have separated sumps. These facilities have ongoing oil spill prevention system projects that will address this once completed.

One current technique to mitigate potential sump oil discharge to the rivers aside from the OWS involves leaving a column of water in the sump, which keeps the floating oil away from pump intakes. Alarms are present on all substantial oil-containing equipment in the powerhouses that would alert operators to a potential release. If a large amount of oil accumulates in the sump, the operator can disable the drainage pump, allowing the sump to act as secondary containment for the oil spill. Then, designated personnel can access the sump and begin the cleanup process using absorbent materials or an oil skimmer.

An individual turbine may contain upwards of a thousand gallons of oil, which has the potential to leak into river water via the oil cooling system, though this is considered unlikely. It was determined to be cost prohibitive to install measures to address oil cooler system leaks, as it would require a significant alteration to the facility that could compromise system safety. Regular replacement of the cooling coils is performed to reduce the risk of such a release.

The final places that oil releases could happen are dam intake towers. Sources of oil include emergency diesel generator fuel tanks and the hydraulic fluid reservoirs that support adjusting the flow of the regulating outlets (ROs). However, both oil sources can be contained with nearby containment berms and modified drain plugs.

#### *3.16.1.7 Fish Collection and Hatchery Chemicals*

USACE operates five adult fish collection facilities and five hatcheries that anesthetize fish with chemicals to minimize stress and damage during handling. These facilities also use a variety of chemicals to control microorganisms and prevent diseases. The majority of these chemicals are not hazardous. The hazardous chemical names, uses, and hazards are shown below in Table 3.16-1.

**Table 3.16-1. Hazardous Chemical Names, Uses, and Hazards at WVS Fish Collection and Hatchery Facilities**

| Chemical trade name | Use | Hazard |
|---|---|---|
| Formalin | Controls parasites, fungi, and protozoa | Flammable; acute oral and inhalation toxicity |
| Ovadine | Disinfects fish eggs | Eye irritant |
| Chloramine-T | Controls fish gill bacterial outbreaks | Skin and eye irritant |
| Diquat | Controls general bacteria | Eye and respiratory system irritant |
| Tricaine-S | Immobilizes and sedates fish | Skin, eye, and respiratory system irritant |

Source: ODFW 2021c; ODFW 2021d; Sigma Aldrich 2021; Syndel 2015; Syndel 2017; Syngenta 2002; Thermofisher 2010

All chemicals are stored in secure locations according to their SDSs and product labels. Chemical storage rooms have containment systems built into their floors and have eyewash and shower stations available.

#### *3.16.1.8 Pesticides*

Herbicides and insecticides are types of pesticides. These chemicals are applied as spot treatments on a small scale as part of routine maintenance in order to prevent the establishment of new invasive species, manage/control existing populations, and enhance habitat for native species.

Species of exotic blackberries, grasses, and weeds are controlled around the Blue River, Cottage Grove, Dexter, Dorena, Fall Creek, Fern Ridge, Foster, Hills Creek, and Lookout Point reservoirs. The most commonly used chemicals are triclopyr choline and glyphosate (USACE 2021a). Triclopyr choline is considered hazardous under 29 CFR 1910.1200 due to acute toxicity and eye irritation (Dow, 2016). Glyphosate is not considered hazardous (Bayer 2020). Flying insects such as hornets and wasps are controlled around structures as needed using a spray containing tetramethrin, which is not considered hazardous (ARI 2014). These chemicals are stored in a secure cabinet in the Fern Ridge office warehouse.

The majority of applications are away from water. When necessary, aquatic-labeled herbicides are applied at least six and a half feet from bodies of water, and extra caution is used when water bodies are bearing anadromous fish. All pesticide use complies with the ESA consultation between the EPA and the NMFS and the National Pollutant Discharge Elimination System (NPDES) Pesticide General Permit issued by the ODEQ. No chemicals are used that are listed on the EPA's Restricted Use Products Report.

### 3.16.2 Environmental Effects

This section discusses the potential effects of the Proposed Action and alternatives to hazardous materials. The discussion includes the methodology used to assess effects, the measures within the action alternatives that were analyzed, a summary of the effects, and a detailed analysis of effects under each alternative.

#### *3.16.2.1 Methodology*

The potential effects to hazardous materials were assessed by examining ongoing trends in the presence and use of hazardous materials (fuel, oil, pesticides, compressed gasses, LBP, ACM) in the WVS, and the subsequent presence of the materials in soil, sediment, air, and water (exposure pathways). Scientific literature, news releases, and documents such as inventories, reports, and SDSs were used to predict the severity of the threat that hazardous materials pose to natural resources and the public over the life of the project. Table 3.16-2 describes the evaluation criteria for the magnitude, duration, and extent, and provides a definition for the scale of each effect factor.

**All comparisons of effects for each action alternative are in comparison to the NAA unless stated otherwise.**

**Table 3.16-2. Evaluation Criteria for Potential Effects to Hazardous Materials**

| Term | Definition |
|---|---|
| **Magnitude** | |
| Negligible | Emission, discharge, or deposition of hazardous materials in soil, sediment, air, and/or water and the environmental effects from such would not be measurable. |
| Minor | Emission, discharge, or deposition of hazardous materials in soil, sediment, air, and/or water and the environmental effects from such would be measurable but near the detection limit. |
| Moderate | Emission, discharge, or deposition of hazardous materials in soil, sediment, air, and/or water and the environmental effects from such would be measurable and moderately above the detection limit. Mitigation measures would be required to offset adverse effects, but long-term changes to the environment would be expected. |
| Major | Emission, discharge, or deposition of hazardous materials in soil, sediment, air, and/or water and the environmental effects from such would be readily measurable and clearly above the detection limit. Mitigation measures would be required to offset adverse effects, but long-term changes to the environment would be expected. |
| **Duration** | |
| Short term | Alteration lasts for the duration of small construction projects, and is continuous for less than 2 years. |
| Medium term | Alteration is limited to the duration of large construction projects, and is continuous for a period of 2-5 years. |
| Long term | Alteration is permanent or lasts continuously beyond operation changes or the completion of all construction projects; the alteration recurs at regular intervals (i.e., deep drawdowns that occur for a 3-week period in the fall and/or spring); or the alteration occurs intermittently. |
| **Extent** | |
| Local | Effects would be confined to the project area. |
| Regional | Effects would be perceived throughout a single county, multiple counties, or the entire WVS. |
| State-wide | Effects would be perceived throughout the entire state. |

#### *3.16.2.2 Measures Analyzed for Hazardous Materials*

Measures under the action alternatives that could affect hazardous materials include: adapt hatchery program (#719); continued operation of existing adult fish facilities; construct adult fish facility (#722); operation, maintenance, repair, replacement and rehabilitation; gravel augmentation below dams (#384); maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9); maintenance of existing and new fish release sites above dams (#726); restore upstream and downstream passage at drop structures

(#639); use spillway for surface spill in summer (#721); provide Pacific lamprey passage and infrastructure (#52); structural improvements to reduce total dissolved gas (#174); Foster fish ladder temperature improvement (#479); construct water temperature control tower (#105); and deeper fall reservoir drawdowns for fish passage (#40). The following measures would not have effects from hazardous materials, and are therefore not discussed further.

- Integrated temperature and habitat flow regime (#30a);
- Refined integrated temperature and habitat flow regime (#30b);
- Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166);
- Augment instream flows by using the inactive pool (#718);
- Augment instream flows by using the power pool (#304);
- Pass water over spillway in spring for fish passage (#714);
- Reduce minimum flows to Congressionally authorized minimum flow requirements (#723);
- Spring reservoir drawdown for downstream fish passage (#720); and
- Fall Creek Drawdown.

A summary of the effects from hazardous materials discussed in the following sections is provided in Table 3.16-3.

Note that where a range of potential effects would occur, the most severe magnitude of adverse effects and the lesser magnitude of beneficial effects for each alternative was listed in this table. For example, if there is a range of minor to moderate adverse effects, moderate adverse effects are included in the table. If beneficial effects would range from minor to moderate, the table includes minor beneficial effects. Said otherwise, the most conservative conclusions of potential effects are presented in the table below in order to avoid overstating potential beneficial effects and understating adverse effects. Also, the extent of effects includes all reservoirs where potential effects would occur, even if the most severe adverse effect or the lesser beneficial effect does not occur at that reservoir. This follows the approach to present the most conservative conclusions in this table; instead of simply omitting reservoirs where less severe or more beneficial effects would occur. Discussions of all adverse and beneficial effects are included below.

**Table 3.16-3. Summary of Effects from Hazardous Materials**

| Effect Factor | | Alternative | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NAA | 1 | 2A | 2B | 3A | 3B | 4 | 5 |
| | Short-Term | | | | | | | |
| Magnitude | Minor adverse | Minor adverse | Minor adverse | Minor adverse | Minor adverse | Minor adverse | Minor adverse | Minor adverse |
| Extent | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) |
| | Medium-Term | | | | | | | |
| Magnitude | Minor adverse | Minor adverse | Minor adverse | Minor adverse | Minor adverse | Minor adverse | Minor adverse | Minor adverse |
| Extent | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) |
| | Long-Term (Permanent, Intermittent, and/or Recurring) | | | | | | | |
| Magnitude | Minor adverse | Minor adverse; negligible beneficial | Minor adverse; negligible beneficial | Minor adverse; negligible beneficial | Minor adverse; negligible beneficial | Minor adverse; negligible beneficial | Minor adverse; negligible beneficial | Minor adverse; negligible beneficial |
| Extent | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) | Local (basin-wide) |
| Duration Type | Permanent | Permanent | Permanent | Permanent | Permanent | Permanent | Permanent | Permanent |

### *3.16.2.3 No Action Alternative*

Under the NAA, the existing O&M of the WVS would continue, which includes water quality, flow, downstream passage, and upstream passage operations. These actions, aside from the continued O&M of existing AFFs, would have no effects from hazardous materials. With respect to hazardous materials, and as stated above in Section 3.16.1, the O&M of the WVS includes construction, demolition, and maintenance (which requires the storage and use of compressed gasses, management of LBP and ACM, and other hazardous materials); fish collection and hatchery chemicals; pesticides; and the operation of oil-filled equipment.

#### *3.16.2.3.1 Fish Collection and Hatchery Chemicals and Pesticides*

Under the NAA, chemicals would continue to be stored and used at the five fish collection and five hatchery facilities. Fish facilities and hatcheries may use hazardous chemicals to clean equipment and anesthetize fish. These facilities are operated in accordance with their NPDES permits as applicable, and the majority of the chemicals are not hazardous as discussed above in Section 3.16.1.6. Pesticides are used basin-wide on an as-needed basis. The chemicals are securely-stored and the majority are also not considered hazardous as discussed above in Section 3.16.1.7. Personnel would adhere to the USACE Hazard Communication Plan, which includes training and wearing PPE as applicable, and as such, the small hazards presented by these chemicals would be adverse and negligible. The fish facilities and hatcheries would continue to discharge in accordance with their NPDES permits as applicable. The effects of pesticide use would be confined to the project area. Therefore, the effects would be local in extent. These activities would occur for the life of the project, so effects would be long term.

#### *3.16.2.3.2 Construction, Demolition, and Maintenance*

Construction and demolition would occur basin-wide under the NAA as a part of routine and non-routine maintenance activities. For example, the removal of a closed underground storage tank is scheduled to occur at the Cougar Project around 2024. Basin-wide maintenance activities, particularly those involving demolition, could potentially release ACM and/or LBP into the air. All maintenance and renovation activities would follow applicable BMPs and environmental regulations to avoid disturbing ACM and LBP. Before removing any materials, suspected areas would be tested for asbestos or LBP as applicable. If ACM is identified, it would be removed and collected by a certified asbestos-abatement contractor. Any contractors removing paint would treat the paint as if it is lead-containing and use a LBP stabilizer to reduce potential hazardous waste generation. After removal, the debris would be tested using the EPA’s Toxicity Characteristic Leachate (TCLP) procedure to determine its waste status. If determined to be hazardous, it would be disposed of in accordance with RCRA. BMPs would also be used where applicable, which may include paint removal gels (to reduce LBP dust) or the use of hooded needle guns that mechanically remove and vacuum up paint residue.

Construction, demolition, and maintenance could require hazardous materials such as diesel and gasoline for fueling equipment; aerosols, solvents, and adhesives for interior decorating; and compressed gasses for welding, cutting, and brazing, depending on the project. USACE mitigates the hazards posed by compressed gasses by adhering to the general requirements for compressed gasses in 29 CFR part 1910.101 and the welding, cutting, and brazing requirements found in 29 CFR part 1910.253. Additionally, BMPs are used, which includes securing cylinders and keeping them away from heat sources. Typically, effects to the environment from hazardous materials used in construction are associated with accidental spills resulting from improper chemical management. Spills could have a wide range of effects depending on the chemical type, quantity, and location of the spill. Some contaminants may affect soil, surface water, groundwater, or any combination thereof. For example, high levels of acute diesel exposure can cause nervous system damage or death in humans and animals (HHS 1995). Toluene, a common solvent and component of fuels, paints, and adhesives, has a moderate chronic toxicity to aquatic life and can cause a range of upper respiratory, cardiac, and reproductive issues (EPA 2016a; NPI No date a; NPI No date b).

Despite these effects, a 2015 study that considered the environmental impacts of construction activities did not rank hazardous material spills to soil or water in the top 20 most important issues (Ansah 2015). This is because the environmental effects from spills at construction sites can be readily mitigated by following BMPs like maintaining a clean working environment and adhering to proper storage and fueling guidelines. Therefore, effects would be adverse and negligible to minor in magnitude. If a spill did occur, it would be limited to the immediate area because the following actions would be taken: stop the source, contain the spill, apply absorbents, and remove affected soil in accordance with applicable BMPs. Therefore, effects would be local in extent. Small maintenance projects could last on the scale of a week, whereas construction and demolition projects may take up to two years or more, so effects would range from short to medium term. These projects would continue to occur for the life of the project, so effects would also be long term.

#### *3.16.2.3.3 Oil-filled Systems*

The greatest concern from hazardous material release into the environment in the WVS comes from the operation of oil-filled systems, which are primarily at hydropower generating facilities. Oil-filled systems are the largest threat due to the volume of stored oil and its proximity to surface water. Oil spills are a possibility when equipment malfunctions or accidents occur. Although other oil-filled equipment exists at hydropower dams, the equipment that presents the greatest oil-spill hazards are electrical transformers and turbines, as well as their auxiliary equipment such as pumps and above-ground storage tanks. However, both risk and severity of oil spills would be reduced through a variety of measures. Engineering and administrative controls are used to prevent and mitigate oil spills in accordance with each facility's SPCC plan. Applicable oil-filled equipment has alarm systems and multiple levels of containment, is regularly inspected and maintained, and operators are trained to detect and respond to oil spills as discussed above in Sections 3.16.1.1 and 3.16.1.5.

The environmental effects of oil spills can vary depending on the amount and type spilled and the water body in question. Effects on vertebrates can range from minor to major nervous system and reproductive damage to individual birds, mammals, and humans, to broader effects such as the decline or loss of key organisms and/or habitats in an ecosystem (EPA 1999; ITOPF No Date).

While no oil discharges have occurred at USACE WVS dams, several have occurred at nearby USACE dams. At the Dalles and John Day dams on the Columbia River, it was estimated that up to several hundred gallons of oil have been spilled into the Columbia River within the past three years. In all cases, USACE responded swiftly by isolating the source of the leak, deploying absorbent pads, booms, and skimmers, and notifying NGOs and partner agencies such as the National Response Center, regional emergency management offices, and the Columbia River Intertribal Fish Commission (USACE 2018d; USACE 2020; USACE 2021b). The eight USACE power-producing dams in the WVS are currently undergoing National Pollutant Discharge Elimination System (NPDES) permit processing, and it is anticipated that they will be permitted to discharge up to 10 parts per million (ppm) of oil and grease per day under Section 402 of the CWA. Because the dams would be permitted to discharge small amounts of oil, effects would be adverse and minor in magnitude. Effects could range from moderate or greater in magnitude if a large spill occurred, however, the likelihood of a large spill is historically low in the WVS. Although NPDES permits typically last for five years, dams would continue to discharge oil for the life of the project, so effects would be long term. Most spills would be contained by berms and drains and applicable equipment would be managed under SPCC plans. Therefore, effects from oil-filled systems would be local in extent because they would be confined to the project area. However, due to the nature of hydroelectric power generation, oil has the potential to enter the nearby water and travel downstream. Therefore, effects could potentially be regional in extent in some situations, such as if a berm overflowed, a drain was clogged, or there was a malfunction in the turbine cooling system (although these situations are unlikely).

#### *3.16.2.3.4 Climate Change*

As discussed in Appendix F, climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB, independent of the WVS O&M over the next 30 years. Climate change would have no effects on hazardous materials through construction, demolition, and repair of buildings and structures, storage and use of compressed gasses, fish collection and hatchery chemicals, management of LBP and ACM, or operation of oil-filled equipment at hydroelectric dams.

Wetter winters and drier summers would be expected to lead to changes in vegetation community composition and distribution over time, as drought tolerant species become more predominant and invasive plants potentially encroach further into communities of native species, as discussed in Section 3.06, Vegetation. Pest species, including those that are invasive, are managed using a variety of pesticides basin-wide. As invasive species proliferate throughout the WVS over time as a result of climate change, the quantity of pesticides used to control them would be expected to increase proportionally. As discussed above in Section 3.16.1.1 and detailed in the Hazard Communication Plan, USACE personnel are informed of and able to identify hazardous chemicals, as well as protect themselves from hazardous chemical exposures using PPE. Further, pesticides are securely stored, many are considered non-hazardous, and the majority of applications are away from water. Therefore, the effects of climate change in combination with the measures under the NAA from hazardous materials would be negligible in magnitude, local in extent, and long-term.

#### *3.16.2.4 Discussion of Effects by Measures*

This section applies the methodology described above to each measure analyzed for the resource to determine the potential effects. Where possible, the discussion of the magnitude and duration of effects is grouped by measures that would have similar effects. The effects by measure or measures will then be referenced in the action alternative's analysis that follows. Gravel augmentation below dams (#384); maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9); maintenance of existing and new fish release sites above dams (#726); operation, maintenance, repair, replacement and rehabilitation; Foster fish ladder temperature improvement (#479); construct water temperature control tower (#105); use spillway for surface spill in summer (#721); structural improvements to reduce total dissolved gas (#174); restore upstream and downstream passage at drop structures (#639); construct adult fish facility (#722); provide Pacific lamprey passage and infrastructure (#52); construct structural downstream fish passage (#392); and deeper fall reservoir drawdowns for fish passage (#40) would require construction as described above in Section 3.1.2.1. The PEIS discuses general, qualitative effects from construction at the programmatic level. Site-specific project details for each construction measure will be determined during the implementation phase. Subsequent tiered NEPA documents will discuss detailed site-specific effects.

##### *3.16.2.4.1 Continued Operation of Existing AFFs*

The effects of continuing the operation of existing AFFs would be negligible in magnitude, local in extent, adverse, and long term.

Existing AFFs use hazardous chemicals for O&M activities such as cleaning equipment and anesthetizing fish. The hazardous chemicals are primarily skin, eye, and/or respiratory irritants, although formalin is also flammable and has acute oral and inhalation toxicity. However, the risk of USACE personnel experiencing effects from these chemicals is very low because employees are briefed and trained on how to identify and avoid chemical hazards and provided with PPE, as discussed above in Section 3.16.1.1. Further, the majority of the chemicals are not hazardous and the facilities would continue to discharge in accordance with their NPDES permits as applicable. Therefore, the effects would be adverse and negligible in magnitude and local in extent. Because the facilities would operate for the lifetime of the project, effects would be long term.

#### *3.16.2.4.2 Adapt Hatchery Program (#719)*

The effects of adapting the hatchery program would be negligible in magnitude, local in extent, beneficial, and long term.

Similar to AFFs, hatcheries also use hazardous chemicals for O&M activities such as cleaning equipment and anesthetizing fish, as discussed above in Section 3.16.2.4.2. Under this measure, hatchery production levels would be adjusted based on the efficacy of fish passage measures: production levels would be decreased as the amount of accessible fish habitat resulting from fish passage measures increases. Therefore, the amount of hazardous chemicals used at hatcheries would decrease proportionally with the production levels, so the effects would be beneficial. The decrease in chemical usage would have a nondetectable effect on the environment because facilities would continue to be operated in accordance with their NPDES permits as applicable, the majority of chemicals are not hazardous, and USACE personnel are briefed and trained on hazards and use PPE as appropriate. Thus, the effects would be negligible in magnitude and local in extent. The changes would last for the duration of the project, so effects would be long term.

Therefore, the potential effects of adapting the hatchery program would be negligible in magnitude, local in extent, beneficial, and long term.

#### *3.16.2.4.3 Operation, Maintenance, Repair, Replacement and Rehabilitation*

The effects of operation, maintenance, repair, replacement, and rehabilitation would be negligible to minor in magnitude, adverse, and local in extent in the short, medium, and long term.

Operation, maintenance, repair, replacement, and rehabilitation can be categorized into scheduled/routine maintenance, and major maintenance and rehabilitation. These actions would have identical effects to those discussed above in Section 3.16.2.3.2 from construction, demolition, and maintenance. Therefore, the effects would be negligible to minor in magnitude, adverse, and local in extent in the short, medium, and long term.

#### *3.16.2.4.4 Gravel augmentation below dams (#384), Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), Maintenance of existing and new fish release sites above dams (#726), Restore upstream and downstream passage at drop structures (#639), Provide Pacific lamprey passage and infrastructure (#52), and Use spillway for surface spill in summer (#721)*

The effects from augmenting gravel below dams; maintaining or altering revetments; maintaining existing and new fish release sites above dams; restoring upstream and downstream passage at drop structures; using the spillway for surface spill in summer (only at Blue River and Hills Creek); and providing Pacific lamprey passage and infrastructure would be negligible to minor in magnitude, local in extent, adverse, and short term.

These measures include short-term construction activities, and hazardous materials could be present, such as gasoline and diesel for fueling equipment and compressed gasses for welding, cutting, and brazing. These activities would have similar effects to those discussed above in Section 3.16.2.3.2 because the environmental effects from spills at construction sites can be minimized by following BMPs like maintaining a clean working environment and adhering to proper storage and fueling guidelines. Therefore, effects would be negligible to minor in magnitude, local in extent, adverse, and short term.

##### *3.16.2.4.5 Structural improvements to reduce total dissolved gas (#174), Foster Fish Ladder Temperature Improvement (#479), Construct adult fish facility (#722), Construct water temperature control tower (#105), Deeper fall reservoir drawdowns for fish passage (#40), and Construct structural downstream fish passage (#392)*

The effects from improving structures to reduce TDG; the Foster fish ladder temperature improvement; constructing AFFs, WTC towers and structural downstream fish passage; and deeper fall drawdowns would be negligible to minor in magnitude, local in extent, adverse, and medium term from construction. Additionally, deeper fall drawdowns (only at Detroit, Green Peter, and Lookout Point) and constructing AFFs, WTC towers, and structural downstream fish passage (excluding Foster) would also have negligible in magnitude, local in extent, long-term effects from operation after construction. Construction effects from the deeper fall drawdown would only occur at Cougar when the reservoir is drawn down to the DT, as this would require the construction of an intake and access tower. Drawdowns would only have medium-term effects when there would be construction associated with it (Cougar in Alternatives 2B and 3B). Similar to the measures discussed above in Sections 3.16.2.3.2 and 3.16.2.4.4, these measures include medium-term construction activities and could require hazardous materials for fueling equipment and cutting, welding, and brazing. Therefore, effects would be negligible to minor in magnitude, local in extent, adverse, and medium term.

WTC towers effectively serve as hydropower turbine intakes and would require oil-filled systems to adjust the gates that control water flows. WTC towers, AFFs, structural downstream fish passage (excluding Foster), and deep fall drawdowns at Detroit, Green Peter, and Lookout Point would require the installation of emergency diesel generators (EDGs) to provide power during an emergency. The EDGs at Detroit, Green Peter, and Lookout Point would be required for deep drawdowns as the current EDG cooling water intakes are located too high to be used during deep drawdowns. These oil-filled systems would provide new, additional sources for potential oil spills during operation. However, construction of these facilities would include berms and drains to prevent spills from reaching the water, and EDGs and any supporting equipment would be added to and managed under facility SPCC plans as applicable. Therefore, effects from oil-filled systems would be adverse and negligible in magnitude as discussed above in Section 3.16.2.3.3. If a spill did occur, it would be limited to the immediate area, so effects would be local in extent. Operations would continue for the life of the project, so the effects would be long term. AFFs would also require hazardous chemicals for fish facility operations as discussed above in Section 3.16.2.3.1, so effects would be negligible in magnitude, local in extent, adverse, and long term.

Therefore, potential adverse effects from improving structures to reduce TDG; the Foster fish ladder temperature improvement; constructing AFFs, WTC towers and structural downstream fish passage; and deeper fall drawdowns would be negligible to minor in magnitude, local in extent, and adverse in the medium-term, and deeper fall drawdowns and constructing AFFs, WTC towers, and structural downstream fish passage (excluding Foster) would also have negligible in magnitude, local in extent, long-term effects from operation after construction.

##### *3.16.2.4.6 Suite of near-term operations*

The majority of the near-term operations involve water-management operations, and thus, would not have effects from hazardous materials. The deep drawdowns at Green Peter and Lookout Point dams would require the installation of an EDG and would provide new, additional sources for potential oil spills during operation as discussed above in Section 3.16.2.4.5. Therefore, the potential adverse effects would be negligible in magnitude, local in extent, adverse, and long term.

#### ***3.16.2.5 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures***

Under Alternative 1, effects of continued operation of existing AFFs would be negligible in magnitude, local in extent, adverse, and long term. Effects of adapting the hatchery program would be negligible in magnitude, local in extent, beneficial, and long term. Effects of operation, maintenance, repair, replacement, and rehabilitation would be negligible to minor in magnitude, adverse, and local in extent in the short, medium, and long term. Effects from augmenting gravel below dams; maintaining or altering revetments; maintaining existing and new fish release sites above dams; restoring upstream and downstream passage at drop structures; and providing Pacific lamprey passage and infrastructure would be negligible to minor in magnitude, local in extent, adverse, and short term. Effects from improving structures to reduce TDG; the Foster fish ladder temperature improvement; constructing AFFs, WTC towers and structural downstream fish passage would be negligible to minor in magnitude, local in extent, adverse, and medium term from construction. Constructing AFFs, WTC towers, and structural downstream fish passage (excluding Foster) would also have negligible in magnitude, local in extent, long-term effects from operations.

Overall, these effects would be greater than alternatives 2A, 2B, 3A, and 3B due to the number of medium-term construction projects.

##### *3.16.2.5.1 Continued operation of existing AFFs*

Under all action alternatives, the operation of existing AFFs would continue at Dexter, Cougar, Foster, Fall Creek, and Minto. As discussed above in Section 3.16.2.4.1, the effects would be negligible in magnitude, local in extent, adverse, and long term.

#### *3.16.2.5.2 Adapt Hatchery Program (#719)*

Under all action alternatives the hatchery programs would be adapted in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins. As discussed above in Section 3.16.2.4.2, the effects would be negligible in magnitude, local in extent, beneficial, and long term.

#### *3.16.2.5.3 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide. As discussed above in Section 3.16.2.4.3, the effects would be negligible to minor in magnitude, adverse, and local in extent in the short, medium, and long term.

#### *3.16.2.5.4 Gravel augmentation below dams (#384), Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), Maintenance of existing and new fish release sites above dams (#726), Restore upstream and downstream passage at drop structures (#639), and Provide Pacific lamprey passage and infrastructure (#52)*

Under all action alternatives, augmenting gravel below dams would occur below Big Cliff, Blue River, Cougar, and Foster, maintaining or altering revetments would occur basin-wide in rivers, and maintenance of existing and new fish release sites would occur basin-wide. Under Alternative 1, restoring upstream and downstream passage at drop structures would occur at Fern Ridge, and providing Pacific lamprey passage and infrastructure would occur at Fern Ridge and Green Peter. As discussed above in Section 3.16.2.4.4, the effects would be negligible to minor in magnitude, local in extent, adverse, and short term.

#### *3.16.2.5.5 Structural improvements to reduce total dissolved gas (#174), Foster Fish Ladder Temperature Improvement (#479), Construct adult fish facility (#722), Construct water temperature control tower (#105); and Construct structural downstream fish passage (#392)*

Under Alternative 1, improving structures to reduce TDG would have effects at Cougar, Dexter, and Foster; the fish ladder temperature improvement would occur at Foster, constructing an AFF would occur at Green Peter, constructing a WTC tower would occur at Detroit, Green Peter, and Lookout Point; and constructing downstream fish passage infrastructure would occur at Detroit, Foster, Green Peter, and Lookout Point. Due to the construction of WTC towers, there would be no separate structural improvement projects to reduce TDG at Detroit, Green Peter, or Lookout Point. Because EDGs would only be required for structural downstream passage using FSSs or FSCs, no EDG would be installed at Foster and thus, there would be no long-term operational effects.

As discussed in Section 3.16.2.4.5, the effects from improving structures to reduce TDG; the Foster fish ladder temperature improvement; constructing an AFF, WTC towers, and structural downstream fish passage would be negligible to minor in magnitude, local in extent, and adverse in the medium-term. The effects from constructing an AFF, WTC towers, and structural downstream fish passage (excluding Foster) would also be negligible in magnitude, local in extent, long-term from operation.

##### *3.16.2.5.6 Climate Change*

Alternative 1 would combine storage-focused measures in order to improve fish passage. These measures would have negligible to minor, adverse and beneficial effects from hazardous materials, but would not contribute to effects from climate change. Therefore, Alternative 1 (and all action alternatives) would result in the same effects from climate change on hazardous materials. As discussed above in Section 3.16.2.3.4, climate change could result in the proliferation of pest species, which may require the increased use of pesticides to control. Because pesticides are securely stored, most are considered non-hazardous, and the majority of applications are away from water, the effects of climate change from hazardous materials would be adverse and negligible in magnitude, local in extent, and long-term.

#### ***3.16.2.6 Alternative 2A – Integrated Water Management Flexibility and ESA Listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam)***

Under Alternative 2A, effects of continued operation of existing AFFs would be negligible in magnitude, local in extent, adverse, and long term. Effects of adapting the hatchery program would be negligible in magnitude, local in extent, beneficial, and long term. Effects of operation, maintenance, repair, replacement, and rehabilitation would be negligible to minor in magnitude, adverse, and local in extent in the short, medium, and long term. Effects from augmenting gravel below dams; maintaining or altering revetments; maintaining existing and new fish release sites above dams; and providing Pacific lamprey passage and infrastructure would be negligible to minor in magnitude, local in extent, adverse, and short term. Effects from effects from improving structures to reduce TDG; the Foster fish ladder temperature improvement; and constructing AFFs, WTC towers and structural downstream fish passage would be negligible to minor in magnitude, local in extent, adverse, and medium term from construction. Deeper fall drawdowns and constructing AFFs, WTC towers, and structural downstream fish passage (excluding Foster) would also have negligible in magnitude, local in extent, long-term effects from operations.

Overall, these effects would be the same as Alternative 3A, greater than Alternatives 2B and 5, but less than Alternatives 3B and 4 due to the number of medium-term construction projects.

##### *3.16.2.6.1 Continued operation of existing AFFs*

Under all action alternatives, the operation of existing AFFs would continue at Dexter, Cougar, Foster, Fall Creek, and Minto. As discussed above in Section 3.16.2.4.1, the effects would be negligible in magnitude, local in extent, adverse, and long term.

#### *3.16.2.6.2 Adapt Hatchery Program (#719)*

Under all action alternatives the hatchery programs would be adapted in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins. As discussed above in Section 3.16.2.4.2, the effects would be negligible in magnitude, local in extent, beneficial, and long term.

#### *3.16.2.6.3 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide. As discussed above in Section 3.16.2.4.3, the effects would be negligible to minor in magnitude, adverse, and local in extent in the short, medium, and long term.

#### *3.16.2.6.4 Gravel augmentation below dams (#384), Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), Maintenance of existing and new fish release sites above dams (#726), and Provide Pacific lamprey passage and infrastructure (#52)*

Under all action alternatives, augmenting gravel below dams would occur below Big Cliff, Blue River, Cougar, and Foster, maintaining or altering revetments would occur basin-wide in rivers, and maintenance of existing and new fish release sites would occur basin-wide. Under Alternative 2A, providing Pacific lamprey passage and infrastructure would occur at Green Peter. As discussed above in Section 3.16.2.4.4, the effects would be negligible to minor in magnitude, local in extent, adverse, and short term.

#### *3.16.2.6.5 Foster Fish Ladder Temperature Improvement (#479), Construct adult fish facility (#722), Construct water temperature control tower (#105); Deeper fall reservoir drawdowns for fish passage (#40), and Construct structural downstream fish passage (#392)*

Under Alternative 2A, the fish ladder temperature improvement would occur at Foster; constructing an AFF would occur at Green Peter, constructing a WTC tower would occur at Detroit; deeper fall drawdowns would have effects at Green Peter (long term); and constructing structural downstream fish passage infrastructure would occur at Cougar, Detroit, Foster, and Lookout Point. Because EDGs would only be required for structural downstream passage using FSSs or FSCs, no EDG would be installed at Foster and thus, there would be no long-term operational effects.

As discussed above in Section 3.16.2.5.5 effects from the Foster fish ladder temperature improvement; constructing an AFF, WTC tower, and structural downstream passage would be negligible to minor in magnitude, local in extent, and adverse in the medium-term. The effects from the deeper fall drawdown and constructing an AFF, WTC towers, and structural downstream fish passage (excluding Foster) would also be negligible in magnitude, local in extent, and long-term from operations.

#### *3.16.2.6.6 Suite of near-term operations*

As discussed above in Section 3.16.2.4.6, the majority of the near-term operations involve water-management operations, and thus, would not have effects from hazardous materials. The deep drawdowns Green Peter and Lookout Point dams would each require the installation of an EDG and would provide new, additional sources for potential oil spills during operation as discussed above in Section 3.16.2.4.5. Therefore, the potential adverse effects would be negligible in magnitude, local in extent, adverse, and long term.

#### *3.16.2.6.7 Climate Change*

Alternative 2A would integrate water management flexibility and ESA-listed fish measures (using structural downstream passage at Cougar Dam). These measures would have negligible to minor, adverse and beneficial effects from hazardous materials, but would not contribute to effects from climate change. Therefore, Alternative 2A (and all action alternatives) would result in the same effects from climate change on hazardous materials. As discussed above in Section 3.16.2.3.4, climate change could result in the proliferation of pest species, which may require the increased use of pesticides to control. Because pesticides are securely stored, most are considered non-hazardous, and the majority of applications are away from water, the effects of climate change from hazardous materials would be adverse and negligible in magnitude, local in extent, and long-term.

### ***3.16.2.7 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)***

Under Alternative 2B, effects of continued operation of existing AFFs would be negligible in magnitude, local in extent, adverse, and long term. Effects of adapting the hatchery program would be negligible in magnitude, local in extent, beneficial, and long term. Effects of operation, maintenance, repair, replacement, and rehabilitation would be negligible to minor in magnitude, adverse, and local in extent in the short, medium, and long term. Effects from augmenting gravel below dams; maintaining or altering revetments; maintaining existing and new fish release sites above dams; and providing Pacific lamprey passage and infrastructure would be negligible to minor in magnitude, local in extent, adverse, and short term. Effects from effects from improving structures to reduce TDG; the Foster fish ladder temperature improvement; constructing AFFs, WTC towers and structural downstream fish passage; and deeper fall drawdowns (at Cougar only) would be negligible to minor in magnitude, local in extent, adverse, and medium term from construction. Deeper fall drawdowns and constructing AFFs, WTC towers, and structural downstream fish passage (excluding Foster) would also be negligible in magnitude, local in extent, long-term effects from operations.

Overall, these effects would be the same as Alternative 5 and less than all other action alternatives because Alternatives 2B and 5 include the fewest short- and medium-term construction projects due to the number of medium-term construction projects that would also result in long-term effects from operations.

##### *3.16.2.7.1 Continued operation of existing AFFs*

Under all action alternatives, the operation of existing AFFs would continue at Dexter, Cougar, Foster, Fall Creek, and Minto. As discussed above in Section 3.16.2.4.1, the effects would be negligible in magnitude, local in extent, adverse, and long term.

##### *3.16.2.7.2 Adapt Hatchery Program (#719)*

Under all action alternatives the hatchery programs would be adapted in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins. As discussed above in Section 3.16.2.4.2, the effects would be negligible in magnitude, local in extent, beneficial, and long term.

##### *3.16.2.7.3 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide. As discussed above in Section 3.16.2.4.3, the effects would be negligible to minor in magnitude, adverse, and local in extent in the short, medium, and long term.

##### *3.16.2.7.4 Gravel augmentation below dams (#384), Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), Maintenance of existing and new fish release sites above dams (#726), and Provide Pacific lamprey passage and infrastructure (#52)*

Under all action alternatives, augmenting gravel below dams would occur below Big Cliff, Blue River, Cougar, and Foster, maintaining or altering revetments would occur basin-wide in rivers, and maintenance of existing and new fish release sites would occur basin-wide. Under Alternative 2B, providing Pacific lamprey passage and infrastructure would occur at Green Peter. As discussed above in Section 3.16.2.4.4, the effects would be negligible to minor in magnitude, local in extent, adverse, and short term.

##### *3.16.2.7.5 Foster Fish Ladder Temperature Improvement (#479), Construct adult fish facility (#722), Construct water temperature control tower (#105), Deeper fall reservoir drawdowns for fish passage (#40), and Construct structural downstream fish passage (#392)*

Under Alternative 2B, the fish ladder temperature improvement would occur at Foster, constructing an AFF would occur at Green Peter, constructing a WTC tower would occur at Detroit; deeper fall drawdowns would have effects at Cougar (medium and long term) and Green Peter (long term); and constructing downstream fish passage infrastructure would occur at Detroit, Foster, and Lookout Point. Because EDGs would only be required for structural downstream passage using FSSs or FSCs, no EDG would be installed at Foster and thus, there would be no long-term operational effects.

As discussed above in Section 3.16.2.5.5 effects from the Foster fish ladder temperature improvement, deeper fall reservoir drawdown (only at Cougar due to construction of the intake and access tower required to use the DT), and constructing an AFF, WTC tower, and structural downstream passage would be negligible to minor in magnitude, local in extent, and adverse in the medium-term. The effects from the deeper fall drawdown and constructing an AFF, WTC towers, and structural downstream fish passage (excluding Foster) would also be negligible in magnitude, local in extent, and long-term from operations.

##### *3.16.2.7.6 Suite of near-term operations*

As discussed above in Section 3.16.2.4.6, the majority of the near-term operations involve water-management operations, and thus, would not have effects from hazardous materials. The deep drawdowns Green Peter and Lookout Point dams would each require the installation of an EDG and would provide new, additional sources for potential oil spills during operation as discussed above in Section 3.16.2.4.5. Therefore, the potential adverse effects would be negligible in magnitude, local in extent, adverse, and long term.

##### *3.16.2.7.7 Climate Change*

Alternative 2B would integrate water management flexibility and ESA-listed fish measures (using a deep drawdown to Cougar Dam's DT). These measures would have negligible to minor, adverse and beneficial effects from hazardous materials, but would not contribute to effects from climate change. Therefore, Alternative 2B (and all action alternatives) would result in the same effects from climate change on hazardous materials. Because pesticides are securely stored, most are considered non-hazardous, and the majority of applications are away from water, the effects of climate change from hazardous materials would be adverse and negligible in magnitude, local in extent, and long-term.

#### ***3.16.2.8 Alternative 3A – Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)***

Under Alternative 3A, effects of continued operation of existing AFFs would be negligible in magnitude, local in extent, adverse, and long term. Effects of adapting the hatchery program would be negligible in magnitude, local in extent, beneficial, and long term. Effects of operation, maintenance, repair, replacement, and rehabilitation would be negligible to minor in magnitude, adverse, and local in extent in the short, medium, and long term. Effects from augmenting gravel below dams; maintaining or altering revetments; maintaining existing and new fish release sites above dams; providing Pacific lamprey passage and infrastructure; and using the spillway for summer surface spill (at Blue River and Hills Creek) would be negligible to minor in magnitude, local in extent, adverse, and short term. Effects from the Foster fish ladder temperature improvement and constructing AFFs would be negligible to minor in magnitude, local in extent, adverse, and medium term from construction. Deeper fall drawdowns (at Detroit, Green peter, and Lookout Point) and constructing AFFs would also be negligible in magnitude, local in extent, and long-term.

Overall, these effects would be the same as Alternative 2A, greater than Alternatives 2B and 5, and less than Alternatives 1, 3B, and 4 due to the number of medium-term construction projects that would also result in long-term effects from operations.

###### *3.16.2.8.1 Continued Operation of Existing AFFs*

Under all action alternatives, the operation of existing AFFs would continue. As discussed above in Section 3.16.2.4.1, the effects would be negligible in magnitude, local in extent, adverse, and long term.

###### *3.16.2.8.2 Adapt Hatchery Program (#719)*

Under all action alternatives the hatchery programs would be adapted in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins. As discussed above in Section 3.16.2.4.2, the effects would be negligible in magnitude, local in extent, beneficial, and long term.

###### *3.16.2.8.3 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide. As discussed above in Section 3.16.2.4.3, the effects would be negligible to minor in magnitude, adverse, and local in extent in the short, medium, and long term.

###### *3.16.2.8.4 Gravel augmentation below dams (#384), Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), Maintenance of existing and new fish release sites above dams (#726), Use spillway for surface spill in summer (#721), and Provide Pacific lamprey passage and infrastructure (#52)*

Under all action alternatives, augmenting gravel below dams would occur below Big Cliff, Blue River, Cougar, and Foster, maintaining or altering revetments would occur basin-wide in rivers, and maintenance of existing and new fish release sites would occur basin-wide. Under Alternative 3A, providing Pacific lamprey passage and infrastructure would occur at Blue River, Green Peter, and Hills Creek, and using the spillway for surface spill in the summer would have effects at Blue River and Hills Creek. As discussed above in Section 3.16.2.4.4, the effects would be negligible to minor in magnitude, local in extent, adverse, and short term.

###### *3.16.2.8.5 Foster Fish Ladder Temperature Improvement (#479), Construct adult fish facility (#722), and Deeper fall reservoir drawdown for fish passage (#40)*

Under Alternative 3A, the fish ladder temperature improvement would occur at Foster; constructing an AFF would occur at Blue River, Green Peter, and Hills Creek and deeper fall drawdowns would have effects at Detroit, Green Peter, and Lookout Point (long term).

As discussed above in Section 3.16.2.5.5 effects from the Foster fish ladder temperature improvement and constructing AFFs would be negligible to minor in magnitude, local in extent, and adverse in the medium-term. The effects from the deeper fall drawdown and constructing AFFs would be negligible in magnitude, local in extent, and long-term.

#### *3.16.2.8.6 Suite of near-term operations*

As discussed above in Section 3.16.2.4.6, the majority of the near-term operations involve water-management operations, and thus, would not have effects from hazardous materials. The deep drawdowns Green Peter and Lookout Point dams would each require the installation of an EDG and would provide new, additional sources for potential oil spills during operation as discussed above in Section 3.16.2.4.5. Therefore, the potential adverse effects would be negligible in magnitude, local in extent, adverse, and long term.

#### *3.16.2.8.7 Climate Change*

Alternative 3A would improve fish passage by using operations-focused measures (using a deep drawdown to Cougars Dam's RO). These measures would have negligible to minor, adverse and beneficial effects from hazardous materials, but would not contribute to effects from climate change. Therefore, Alternative 3A (and all action alternatives) would result in the same effects from climate change on hazardous materials. As discussed above in Section 3.16.2.3.4, climate change could result in the proliferation of pest species, which may require the increased use of pesticides to control. Because pesticides are securely stored, most are considered non-hazardous, and the majority of applications are away from water, the effects of climate change from hazardous materials would be adverse and negligible in magnitude, local in extent, and long-term.

### ***3.16.2.9 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)***

Under Alternative 3B, effects of continued operation of existing AFFs would be negligible in magnitude, local in extent, adverse, and long term. Effects of adapting the hatchery program would be negligible in magnitude, local in extent, beneficial, and long term. Effects of operation, maintenance, repair, replacement, and rehabilitation would be negligible to minor in magnitude, adverse, and local in extent in the short, medium, and long term. Effects from augmenting gravel below dams; maintaining or altering revetments; maintaining existing and new fish release sites above dams; providing Pacific lamprey passage and infrastructure; and using the spillway for summer surface spill (at Blue River and Hills Creek) would be negligible to minor in magnitude, local in extent, adverse, and short term. Effects from the Foster fish ladder temperature improvement, constructing AFFs and deeper fall drawdowns (at Cougar only) would be negligible to minor in magnitude, local in extent, adverse, and medium term from construction. Effects from deeper fall drawdowns and constructing AFFs would also be negligible in magnitude, local in extent, and long-term.

Overall, these effects would be greater than Alternatives 2A, 2B, and 5, but less than Alternatives 1 and 4 due to the number of medium-term construction projects that would also result in long-term effects from operations.

##### *3.16.2.9.1 Continued Operation of Existing AFFs*

Under all action alternatives, the operation of existing AFFs would continue. As discussed above in Section 3.16.2.4.1, the effects would be negligible in magnitude, local in extent, adverse, and long term.

##### *3.16.2.9.2 Adapt Hatchery Program (#719)*

Under all action alternatives the hatchery programs would be adapted in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins. As discussed above in Section 3.16.2.4.2, the effects would be negligible in magnitude, local in extent, beneficial, and long term.

##### *3.16.2.9.3 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide. As discussed above in Section 3.16.2.4.3, the effects would be negligible to minor in magnitude, adverse, and local in extent in the short, medium, and long term.

##### *3.16.2.9.4 Gravel augmentation below dams (#384), Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), Maintenance of existing and new fish release sites above dams (#726), Provide Pacific lamprey passage and infrastructure (#52), and Use spillway for surface spill in summer (#721);*

Under all action alternatives, augmenting gravel below dams would occur below Big Cliff, Blue River, Cougar, and Foster, maintaining or altering revetments would occur basin-wide in rivers, and maintenance of existing and new fish release sites would occur basin-wide. Under Alternative 3B, providing Pacific lamprey passage and infrastructure would occur at Blue River, Green Peter, and Hills Creek, and using the spillway for surface spill in the summer would have effects at Blue River and Hills Creek. As discussed above in Section 3.16.2.4.4, the effects would be negligible to minor in magnitude, local in extent, adverse, and short term.

##### *3.16.2.9.5 Foster Fish Ladder Temperature Improvement (#479), Construct adult fish facility (#722), and Deeper fall reservoir drawdowns for fish passage (#40)*

Under Alternative 3B, the fish ladder temperature improvement would occur at Foster; constructing AFFs would occur at Blue River, Green Peter, and Hills Creek; and deeper fall drawdowns would have effects at Cougar (medium and long term), Detroit, Green Peter, and Lookout Point (long term).

As discussed above in Section 3.16.2.5.5 effects from the Foster fish ladder temperature improvement; deeper fall reservoir drawdown (only at Cougar due to construction of the intake and access tower required to use the DT), and constructing AFFs would be negligible to minor in magnitude, local in extent, and adverse in the medium-term. The effects from the deeper fall drawdown and constructing AFFs would also be negligible in magnitude, local in extent, and long-term.

#### *3.16.2.9.6 Suite of near-term operations*

As discussed above in Section 3.16.2.4.6, the majority of the near-term operations involve water-management operations, and thus, would not have effects from hazardous materials. The deep drawdowns Green Peter and Lookout Point dams would each require the installation of an EDG and would provide new, additional sources for potential oil spills during operation as discussed above in Section 3.16.2.4.5. Therefore, the potential adverse effects would be negligible in magnitude, local in extent, adverse, and long term.

#### *3.16.2.9.7 Climate Change*

Alternative 3B would improve fish passage by using operations-focused measures (using a deep drawdown to Cougar Dam's RO). These measures would have negligible to minor, adverse and beneficial effects from hazardous materials, but would not contribute to effects from climate change. Therefore, Alternative 3B (and all action alternatives) would result in the same effects from climate change on hazardous materials. As discussed above in Section 3.16.2.3.4, climate change could result in the proliferation of pest species, which may require the increased use of pesticides to control. Because pesticides are securely stored, most are considered non-hazardous, and the majority of applications are away from water, the effects of climate change from hazardous materials would be adverse and negligible in magnitude, local in extent, and long-term.

### ***3.16.2.10 Alternative 4 – Structures-Based Fish Passage Alternative***

Under Alternative 4, effects of continued operation of existing AFFs would be negligible in magnitude, local in extent, adverse, and long term. Effects of adapting the hatchery program would be negligible in magnitude, local in extent, beneficial, and long term. Effects of operation, maintenance, repair, replacement, and rehabilitation would be negligible to minor in magnitude, adverse, and local in extent in the short, medium, and long term. Effects from augmenting gravel below dams; maintaining or altering revetments; maintaining existing and new fish release sites above dams; restoring upstream and downstream passage at drop structures; and providing Pacific lamprey passage and infrastructure would be negligible to minor in magnitude, local in extent, adverse, and short term. Effects from improving structures to reduce TDG; the Foster fish ladder temperature improvement and constructing AFFs, WTC towers and structural downstream fish passage would be negligible to minor in magnitude, local in extent, adverse, and medium term from construction. Constructing AFFs, WTC towers, and structural downstream fish passage (excluding Foster) would also have negligible in magnitude, local in extent, long-term effects from operations.

Overall, these effects would be greater than all other action alternatives due to the number of medium-term construction projects that would occur.

*3.16.2.10.1 Adapt Hatchery Program (#719)*

Under all action alternatives the hatchery programs would be adapted in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins. As discussed above in Section 3.16.2.4.2, the effects would be negligible in magnitude, local in extent, beneficial, and long term.

*3.16.2.10.2 Continued Operation of Existing AFFs*

Under all action alternatives, the operation of existing AFFs would continue at Dexter, Cougar, Foster, Fall Creek, and Minto. As discussed above in Section 3.16.2.4.1, the effects would be negligible in magnitude, local in extent, adverse, and long term.

*3.16.2.10.3 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide. As discussed above in Section 3.16.2.4.3, the effects would be negligible to minor in magnitude, adverse, and local in extent in the short, medium, and long term.

*3.16.2.10.4 Gravel augmentation below dams (#384), Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), Maintenance of existing and new fish release sites above dams (#726), Restore upstream and downstream passage at drop structures (#639), and Provide Pacific lamprey passage and infrastructure (#52)*

Under all action alternatives, augmenting gravel below dams would occur below Big Cliff, Blue River, Cougar, and Foster, maintaining or altering revetments would occur basin-wide in rivers, and maintenance of existing and new fish release sites would occur basin-wide. Under Alternative 4, restoring upstream and downstream passage at drop structures would occur at Fern Ridge, and providing Pacific lamprey passage and infrastructure would occur at Fern Ridge and Hills Creek. As discussed above in Section 3.16.2.4.4, the effects would be negligible to minor in magnitude, local in extent, adverse, and short term.

*3.16.2.10.5 Structural improvements to reduce total dissolved gas (#174), Foster Fish Ladder Temperature Improvement (#479), Construct adult fish facility (#722), Construct water temperature control tower (#105), and Construct structural downstream fish passage (#392)*

Under Alternative 4, improving structures to reduce TDG would have effects at Cougar, Dexter, Green Peter, and Foster; the fish ladder temperature improvement would occur at Foster, constructing an AFF would occur at Hills Creek, constructing WTC towers would occur at Detroit, Hills Creek, and Lookout Point; and constructing downstream fish passage infrastructure would occur at Cougar, Detroit, Foster, Hills Creek, and Lookout Point. Due to the construction of WTC towers, there would be no separate structural improvement projects to reduce TDG at Detroit or Lookout Point. Because EDGs would only be required for structural downstream passage using FSSs or FSCs, no EDG would be installed at Foster and thus, there would be no long-term operational effects.

As discussed in Section 3.16.2.4.5, the effects from improving structures to reduce TDG; the Foster fish ladder temperature improvement; constructing an AFF, WTC towers, and structural downstream fish passage would be negligible to minor in magnitude, local in extent, and adverse in the medium-term. The effects from constructing an AFF, WTC towers, and structural downstream fish passage (excluding Foster) would also be negligible in magnitude, local in extent, long-term from operation.

#### *3.16.2.10.6 Suite of near-term operations*

As discussed above in Section 3.16.2.4.6, the majority of the near-term operations involve water-management operations, and thus, would not have effects from hazardous materials. The deep drawdowns Green Peter and Lookout Point dams would each require the installation of an EDG and would provide new, additional sources for potential oil spills during operation as discussed above in Section 3.16.2.4.5. Therefore, the potential adverse effects would be negligible in magnitude, local in extent, adverse, and long term.

#### *3.16.2.10.7 Climate Change*

Alternative 4 would improve fish passage with structures-based measures. These measures would have negligible to minor, adverse and beneficial effects from hazardous materials, but would not contribute to effects from climate change. Therefore, Alternative 4 (and all action alternatives) would result in the same effects from climate change on hazardous materials. As discussed above in Section 3.16.2.3.4, climate change could result in the proliferation of pest species, which may require the increased use of pesticides to control. Because pesticides are securely stored, most are considered non-hazardous, and the majority of applications are away from water, the effects of climate change from hazardous materials would be adverse and negligible in magnitude, local in extent, and long-term.

### ***3.16.2.11 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)***

Alternative 5 would only differ from Alternative 2B by way of the refined integrated temperature management and habitat flow regime measure (#30b), which is not a measure that would have effects from hazardous materials. Therefore, the effects of Alternative 5 would be identical to those of Alternative 2B and less than all other action alternatives because Alternatives 2B and 5 include the fewest short- and medium-term construction projects that would also result in long-term effects from operations.

#### *3.16.2.12 Conclusion*

Severity of adverse effects on hazardous materials is primarily driven by the number of medium-term construction projects, particularly, those that would require the installation of oil-filled equipment and subsequently also result in long-term effects. The action alternatives organized in order of least-severe to most-severe adverse effects on hazardous materials would be: 2B/5, 2A and 3A, 3B, 1, and 4, although there would only be small differences in the level of adverse effects between Alternatives 2B/5, 2A, 3A, and 3B (i.e., Alternatives 1 and 4 would be markedly more severe than the other action alternatives). Differences between the action alternatives would not contribute to effects from climate change on hazardous materials. Therefore, all action alternatives would result in equal effects from climate change with respect to hazardous materials.

## 3.17 PUBLIC HEALTH AND SAFETY – HARMFUL ALGAL BLOOMS

### 3.17.1 Affected Environment

This section describes the existing conditions and occurrences of harmful algal blooms (HABs) within the waters of the WVS. For more information on HABs see section 3.5.

#### *3.17.1.1 What are HABs?*

HABs occur when colonies of algae — simple plants that can be found in freshwater sources such as rivers, lakes, and streams — grow out of control and produce toxic or harmful effects on people, fish, shellfish, marine mammals and birds. Algae and algal blooms are a natural occurrence in marine ecosystems and brackish waters (mixtures of fresh and salt water). Algae cycle nutrients and support the aquatic food web (Burford et al. 2019). However, there are a few forms of algae that are harmful to humans and animals. These include benthic algae, macroalgae, phytoplankton, and cyanobacteria.

Cyanobacteria, also known as blue-green algae, are a form of algae that can produce toxins, which often cause HAB occurrences in freshwater (NOAA 2021). Cyanobacteria HABs can be harmful to humans, pets, wildlife, and livestock if consumed in water and are also responsible for mass fish kills (Gilbert et al. 2005). HAB "events" can last for a short duration and then subside, potentially recurring again the following year. HAB events cannot be predicted as each event is dependent on certain physical and biological conditions discussed below (NOAA 2021).

HAB events have the potential to occur in surface waters used for recreation and those which supply public drinking water such as reservoirs, lakes, and rivers, posing a threat to public health and drinking water supplies (see section 3.19 on Public Health and Safety – Drinking Water). For example, in 2011, the Great Lakes had a record-setting HAB event in Lake Erie with an algal bloom that covered 5,000 square kilometers ($km^2$), shutting down the water supply for over half a million people for several days (Burford et al, 2019). Water treatment facilities implemented additional filtration steps in order to treat the algae and public warnings were issued (NASA 2021).

The number of HAB events have been observed by the scientific community to be increasing nationally and globally. This is largely due to increased levels of human activities such as agriculture and aquaculture, overfishing of top predatory fish causing disruption in the food chain, and ballast water discharge, as these can all lead to an increase in nutrients discharged to water (Gilbert et al. 2005). Global climate change also increases the incidence of HABs. Warmer temperatures, declining pH due to increased $CO_2$, and limitation of light are also conducive to the rapid growth of cyanobacteria blooms, causing HABs to dominate the water surface (Gilbert 2020).

Domestic and industrial waste are also known contributors to eutrophication (or excess nutrients in water bodies) and subsequent increased HAB growth. The increase in the amount of nutrients in a water body is not as critical to HAB growth as the proportion of nitrogen to phosphorus in the water. Changes in nutrient limitation of either nitrogen or phosphorus can change the composition of some algae, resulting in HABs (King County 2003).

### 3.17.2 HABs in the WVS

Natural seasonal algal blooms occur in the WVS reservoirs; however, as discussed in Section 3.6, Water Quality, HABs have been detected in 10 of the 13 WVS reservoirs in the past 16 years. These include the Detroit, Big Cliff, Cougar, Blue River, Dexter, Falls Creek, Hills Creek, Lookout Point, Dorena, and Fern Ridge reservoirs. The Oregon Health Authority (OHA) runs a HABs surveillance program and lists reservoirs for public advisory on the OHA website. The advisory is based on World Health Organization (WHO) guidelines for monitoring visible scum, toxicity levels, or cyanobacteria cell counts (ODEQ, 2011). Currently, observed algal blooms are reported to the District water quality staff. The District water quality staff will take samples when possible and report the results to OHA. Figure 3.5-53 indicates the number of days that the reservoirs have been listed for public advisory since 2005.

Both nutrients from fertilizers used in rural watersheds and runoff from streets in the urban areas near the reservoirs can contribute to excess nutrient loads in the reservoirs. Compared to natural lakes, reservoirs have a different assimilative capacity (i.e., the ability for the reservoir to cleanse itself from pollutants). The reservoir size relative to the drainage area, the typically elongated shape of reservoirs and outlet structures, and mixing processes within the reservoir can all affect nutrient loading. These factors could explain why HABs are more common in reservoirs than in natural lakes (ODEQ 2011).

Common cyanobacteria occurring in lakes and reservoirs in Oregon include *Microcystis*, *Aphanizomenon*, *Gloeotrichia*, *Anabaena*, *Lyngbya*, and *Phormidium* (ODEQ 2011). Section 3.6, Water Quality, discusses the history of HABs in the ten WVS reservoirs where they have been detected. The species of cyanobacteria contributing to the HAB events in WVS reservoirs are listed Table 3.17-1 below.

**Table 3.17-1. Species of Cyanobacteria Contributing to HABs events in WVS Reservoirs.**

| Sub-basin | Reservoir | Species |
|---|---|---|
| North Santiam | Detroit, Big Cliff | *Dolichospermum spp.* (previously *Anabaena spp.*) |
| McKenzie | Cougar, Blue River | *Anabaena spp.* and *Aphanizomenon spp.* |
| Middle Fork | Dexter, Fall Creek, Hill Creek, Lookout Point | *Gloeotrichia spp*., *Dolichospermum spp*., and *Aphanizomenon spp.* |
| Coast Fork and Long Tom | Dorena, Fern Ridge | *Gloeotrichia spp*., *Aphanizomenon spp*., *Dolichospermum spp*., and *Microcystis spp*. |

Source: See Section 3.6, Water Quality

### 3.17.3 Public Health Concerns

The Harmful Algal Bloom and Hypoxia Research and Control Amendments Act (HABHRCA) was enacted by Congress in 2014. It requires the National Oceanic and Atmospheric Administration

(NOAA) and the U.S. Environmental Protection Agency (EPA) to advance the science and research of HABs to control and mitigate their occurrences (EPA 2021f). The EPA has the statutory authority to determine if a HABs event is an "event of national significance". The EPA's national 10-day health advisory levels are provided in Table 3.17-2 below. If cyanotoxins occur in tap water above these levels over 10-day exposure durations, people are at risk of adverse health effects.

**Table 3.17-2. EPA 10-Day Health Advisories**

| 10-Day Health Advisories | Level |
|---|---|
| **Microcystins** | |
| Children pre-school age and younger (under 6 years old) | 0.3 µg/L |
| School-age children (6 years and older) | 1.6 µg/L |
| **Cylindrospermopsin** | |
| Children pre-school age and younger (under 6 years old) | 0.7 µg/L |
| School-age children (6 years and older) | 3.0 µg/L |

Source: EPA Harmful Algal Blooms and Drinking Water Factsheet (EPA 2016b)
µg/L = micrograms per liter

Certain cyanobacteria can produce toxins which can affect the nervous system, liver, or skin and can cause eye or ear irritation. Diarrhea and vomiting can also occur if cyanobacteria are ingested (ODEQ 2011). Microcystins are the most common cyanobacterial HAB toxins that can cause liver toxins resulting in gastrointestinal illnesses for humans. These illnesses can be debilitating and in rare cases fatal (NOAA 2021).

Low levels of cyanotoxins can be removed with conventional water treatment. However, during severe HABs events drinking water requires additional treatment which can be challenging. The properties of the cyanotoxins (intracellular versus extracellular), growth patterns, species, and available types of treatment must be understood in order to control the levels of cyanotoxins in drinking water. To prevent health risks during severe HAB events, water system managers and decisionmakers must take certain steps including adjusting filtration and treatment, monitoring algal blooms, and issuing public health warnings (EPA 2016b). OHA posts public recreational advisories warning the public to avoid water contact. Groundwater and surface water sources that communities rely on for public drinking water are located downstream of the WVS reservoirs. Water is drawn directly from Dexter Reservoir by the City of Lowell for drinking water.

### 3.17.4 HABS Control Methods

The management of cyanobacteria HABs requires monitoring, mitigation, and prediction. The most effective management measure is mitigation through nutrient reduction. Nutrient reduction in the watershed through methods such as stormwater management, sewage treatment facility upgrades, control of erosion in the watershed, and reduction of nutrients from cattle farms and agriculture is the best long-term strategy, but it can take decades for this to be effective. (Burford et al. 2019).

There are common physical and chemical control methods for waterbody management that can be implemented to control cyanobacterial HABs. The EPA recommends physical water control methods such as aeration, hydrologic manipulations of inflow and outflow, mechanical mixing (i.e., circulation), reservoir drawdown/desiccation, surface skimming, and ultrasound devices that emit ultrasonic waves that destroy the cellular structure of cyanobacteria. Chemical control methods include the use of algaecides, barley straw, coagulation, and flocculation (EPA 2020b).

In 2017, the Corps evaluated several other physical methods to control HABs including hypolimnetic withdrawals and horizontal flushing (USACE 2017h). Hypolimnetic withdrawals release cooler water from the lower layers of a reservoir and allow the warmer layers of the surface to reach lower depths. This mixing action can decrease temperatures and create less suitable conditions for HABs to develop. With this method, however, the reservoir withdrawals can limit mixing to localized areas next to the area of withdrawal. This could increase turbidity, which could in turn affect beneficial phytoplankton, and loss of the cooler water could affect downstream temperature targets.

Horizontal flushing is another HAB control method reviewed by the Corps in 2017 (USACE 2017h). This method requires the upper layer of the reservoir to be flushed using high-velocity water jets to allow mixing. However, the turnover created by this mixing could allow nutrients from the lower level to reach the upper water column where the HAB species occur. This method is also disadvantageous as it is difficult to implement over a large area.

Another HAB control method evaluated by the Corps involved blocking sunlight using floating artificial covers and floating balls to reduce the growth of algae in drinking water reservoirs (USACE 2017h). This method, used by the Los Angeles Department of Water and Power, was effective in reducing evaporation and limiting algal growth. Disadvantages that may result from using this method include the costs to maintain the artificial covers and floating balls in areas with winter ice cover and the potential for sunlight blocking to impact the ecosystem due to decreased dissolved oxygen.

### 3.17.5 Environmental Effects

This section discusses the potential effects of the Proposed Action and alternatives on Public Health and Safety – Harmful Algal Blooms. The discussion includes the methodology, the measures within the action alternatives that were analyzed, a summary of the effects, and a detailed analysis for each alternative.

#### *3.17.5.1 Methodology*

The methodology below is used to assess the No Action Alternative (NAA) and the action alternatives' effects on the formation of HABs within the WVS with respect to public health and safety. The formation of HABs is dependent on several environmental factors as described in Section 3.17.1 and can be difficult to predict. The measures for the NAA and action alternatives may enhance the accumulation of HABs or may be beneficial towards the reduction and prevention of HABs. Measures that would contribute to eutrophication including increased sedimentation and nutrients in a water body would have adverse effects because the likelihood of a HABs event would increase. Measures that would prevent HABs events would have beneficial effects and include those in which the continual flow of water would prevent stagnant waters. HABs can last for several days or up to one year or more in a given location and can occur over a small localized area or the entire reservoir and the downstream reaches. Table 3.17-3 describes the evaluation criteria for the effect factors (magnitude, duration, and extent), and provides a definition for the scale of each effect factor.

**All comparisons of effects for each action alternative are in comparison to the NAA unless stated otherwise.**

**Table 3.17-3. Evaluation Criteria for Potential Effects to Public Health and Safety – HABs**

| Effect Factors and Scale | Definition |
|---|---|
| **Magnitude** | |
| Negligible | Public health and safety would not be affected, or changes or benefits would be either nondetectable or, if detected by monitoring or exposure to unsafe conditions from a HAB event, would have effects that would be slight and temporary. Chemical or physical changes to water quality would be temporary and within regulatory standards for water quality conditions for recreation or drinking water supply. No mitigation measures would be necessary. |
| Minor | Changes to public health and safety would be measurable if detected by monitoring or exposure to unsafe conditions from a HAB event, although the changes would be small. Chemical or physical changes to water quality would be detectable by monitoring or exposure to unsafe conditions, but would be within regulatory standards for water quality conditions for recreation or drinking water supply. No mitigation measures would be necessary. |
| Moderate | Changes to public health and safety would be measurable by monitoring or exposure to unsafe conditions from a HAB event and would have adverse or beneficial effects on the affected water body and any affected local downstream receiving waters for recreation or drinking water supply. Chemical or physical changes to water quality would be below regulatory standards for water conditions suitable for recreation and drinking water supply. Mitigation measures would be necessary |

| Effect Factors and Scale | Definition |
|---|---|
| | if the affected water body and local downstream receiving waters are used for recreation or drinking water. |
| Major or Significant | Changes to public health and safety would be readily apparent, either severely adverse or exceptionally beneficial, and result in substantial, noticeable effects on the affected water body and any affected local downstream receiving waters for recreation or drinking water supply. The effects would be detectable by monitoring or exposure to unsafe conditions from a HAB event. Chemical or physical changes to water quality would be well below regulatory standards for water quality conditions suitable for recreation and drinking water supply. Adverse effects could not be reduced using mitigation measures for treating the HAB. |
| **Duration** | |
| Short-term | Effects last for the duration of small construction projects and are continuous for less than 2 years. |
| Medium-term | Effects are limited to the duration of large construction projects and is continuous for a period of 2-5 years. |
| Long-term | Effects are permanent or last continuously beyond operational changes or the completion of all construction projects; effects recur at regular intervals (e.g., deep drawdowns that occur for a 3-week period in the fall and/or spring); or effects occur intermittently. |
| **Extent** | |
| Small | Effects would be confined to a small area (e.g., the inflow to the dam, the area surrounding the principal inlet, along the shoreline of the reservoir, downstream of the dam, or the project area). |
| Medium | Effects occur in the entire reservoir. |
| Large | Effects occur in the entire reservoir and downstream receiving water body. |

#### *3.17.5.2 Measures Analyzed for Public Health and Safety – HABs*

Measures under the action alternatives that could impact Public Health and Safety – HABs include:

- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9);
- Foster fish ladder temperature improvement (#479);
- Construct water temperature control (WTC) towers (#105);
- Use regulating outlets (ROs) to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166);
- Use spillway for surface spill in summer (#721);
- Structural improvements to reduce total dissolved gas (#174);
- Augment instream flows by using the inactive pool (#718);
- Augment instream flows by using the power pool (#304);
- Reduce minimum flows to Congressionally authorized minimum flow requirements (#723);
- Integrated temperature and habitat flow regime (#30a);
- Refined integrated temperature and habitat flow regime (#30b)
- Restore upstream and downstream passage at drop structures (#639);
- Construct adult fish facility (AFF) (#722);
- Provide Pacific lamprey passage and infrastructure (#52);
- Construct structural downstream fish passage (#392);
- Deeper fall reservoir drawdowns for fish passage (#40);
- Spring reservoir drawdown for fish downstream fish passage (#720); and
- Pass water over spillway in spring for fish passage (#714).
- Fall Creek drawdown;
- Continued operation of existing adult fish facilities;
- Operation, maintenance, repair, replacement, and rehabilitation;
- Near-term Operations Measure

The following measures would have no effect on Public Health and Safety – HABs and are therefore not discussed further.

- Gravel augmentation below dams (#384);

- Adapt hatchery program (#719);
- Maintenance of existing and new fish release sites above dams (#726).

A summary of the Public Health and Safety – HABs effects discussed in the sections below is provided in Table 3.17-4.

Note that where a range of potential effects would occur, the most severe magnitude of adverse effects and the lesser magnitude of beneficial effects for each alternative was listed in this table. For example, if there is a range of minor to moderate adverse effects, moderate adverse effects are included in the table. If beneficial effects would range from minor to moderate, the table includes minor beneficial effects. Said otherwise, the most conservative conclusions of potential effects are presented in the table below in order to avoid overstating potential beneficial effects and understating adverse effects. Also, the extent of effects includes all reservoirs where potential effects would occur, even if the most severe adverse effect or the lesser beneficial effect does not occur at that reservoir. This follows the approach to present the most conservative conclusions in this table; instead of simply omitting reservoirs where less severe or more beneficial effects would occur. Discussion of all adverse and beneficial effects are included below.

**Table 3.17-4. Summary of Effects to Public Health and Safety – HABs Under Each Alternative**

| Effect Factor | NAA | Alternative 1 | 2A | 2B | 3A | 3B | 4 | 5 |
|---|---|---|---|---|---|---|---|---|
| | **Short-Term** | | | | | | | |
| Magnitude | Beneficial minor; beneficial and adverse minor | Beneficial and/or adverse minor | Beneficial and/or adverse minor | Beneficial and/or adverse minor | Beneficial and/or adverse minor | Beneficial and/or adverse minor | Beneficial and/or adverse minor | Beneficial and/or adverse minor |
| Extent | Small, large (basin-wide, FOS, DET, FCR, CGR, DEX, BCL, LOP, HCR, CGR) | Small, large (basin-wide, FOS, DET, FRN, GPR, CGR, DEX, LOP, BLU, CTG, DOR, FCR, HCR) | Small, large (basin-wide, FOS, DET, GPR, CGR, LOP, BCL, DEX, GPR) | Small, large (basin-wide, FOS, DET, LOP, BCL, DEX, GPR, BLUE, FCR, CGR, HCR) | Small, large (basin-wide, BLU, GPR, HCR, DET, LOP, FOS, CTG, DOR, FCR, CGR, BCL) | Small, large (basin-wide, BLU, GPR, HCR, DET, LOP, FOS, CTG, DOR, FCR, CGR, BCL) | Small, large (basin-wide, FOS, FRN, HCR, CGR, DET, DEX, GPR, LOP, BLU, CTG, DOR, FCR, BLU) | Small, large (basin-wide, FOS, DET, GPR, LOP, BCL, DEX, BLU, FCR, HCR, CGR) |
| | **Medium-Term** | | | | | | | |
| Magnitude | Adverse negligible | Adverse negligible | Adverse negligible | Adverse negligible | Adverse negligible | Adverse negligible | Adverse negligible | Negligible adverse |
| Extent | Small (basin-wide) | Small (basin-wide, FOS, DET, FRN, CGR, GPR, LOP, BCL, DEX, FRN, CGR, DEX) | Small (basin-wide, FOS, DET, CGR, LOP, BCL, DEX, GPR) | Small (basin-wide, FOS, DET, GPR, LOP, BCL, DEX) | Small (basin-wide, BLU, GPR, HCR, DET, FOS, LOP, CGR, FCR, BCL) | Small (basin-wide, BLU, GPR, HCR, DET, FOS, LOP, CGR, FCR, BCL) | Small (basin-wide, FOS, FRN, HCR, CGR, DET, DEX, GPR, LOP) | Small (basin-wide, FOS, DET, GPR, LOP, BCL, DEX) |
| | **Long-Term (Permanent, Intermittent, or Recurring)** | | | | | | | |
| Magnitude | Beneficial minor; beneficial | Beneficial and/or adverse minor | Beneficial and/or adverse minor | Beneficial and/or adverse minor | Beneficial and/or adverse minor | Beneficial and/or adverse minor | Beneficial and/or adverse minor | Beneficial and/or adverse minor |

| Effect Factor | | Alternative | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NAA | 1 | 2A | 2B | 3A | 3B | 4 | 5 |
| | and adverse minor | | | | | | | |
| Extent | Small, large (basin-wide, FOS, DET, FCR, CGR, DEX, BCL, LOP, HCR, CGR) | Small, large (basin-wide, FOS, DET, FRN, GPR, CGR, DEX, LOP, BLU, CTG, DOR, FCR, HCR) | Small, large (basin-wide, FOS, DET, GPR, CGR, LOP, BCL, DEX, GPR) | Small, large (basin-wide, FOS, DET, LOP, BCL, DEX, GPR, BLUE, FCR, CGR, HCR) | Small, large (basin-wide, BLU, GPR, HCR, DET, LOP, FOS, CTG, DOR, FCR, CGR, BCL) | Small, large (basin-wide, BLU, GPR, HCR, DET, LOP, FOS, CTG, DOR, FCR, CGR, BCL) | Small, large (basin-wide, FOS, FRN, HCR, CGR, DET, DEX, GPR, LOP, BLU, CTG, DOR, FCR, BLU) | Small, large (basin-wide, FOS, DET, GPR, LOP, BCL, DEX, BLU, FCR, HCR, CGR) |
| Duration Type | Recurring | Permanent and/or recurring | Recurring | Recurring | Recurring | Recurring | Permanent and/or recurring | Permanent and/or recurring |

In the following subsections, effects are discussed by measure(s) and subsequently for the (NAA), for each proposed measure that could have an impact, and for each of the action alternatives.

#### *3.17.5.3 Discussion of Effects by Measure(s)*

This section applies the methodology described above to each measure analyzed for the resource to determine the potential effects. Where possible, the discussion of the magnitude and duration of effects is grouped by measures that would have similar effects. The effects by measure or measures will then be referenced in the action alternative's analysis that follows. The extent of effects is discussed by dam/reservoir under the appropriate alternative.

Site-specific project details for each construction measure would be determined during the preconstruction engineering and design phase. While general, qualitative effects from construction are discussed below on a programmatic level, a more detailed, site-specific analysis will be included in a tiered EA or EIS.

##### *3.17.5.3.1 Construction and/or Modification of Structural Measures*

The construction of structural measures would require the use of large equipment which could lead to erosion and sedimentation from exposed soils causing sediment to discharge into the reservoirs. Discharges associated with construction activities could affect public health and safety as sediment-laden runoff could contribute to a HABs event locally. However, construction activities are required to meet NPDES permit requirements for stormwater discharges, and as such adverse, short- and medium-term effects would be negligible as measures to prevent erosion and sedimentation would be implemented during construction. These measures could include the stabilization of exposed soils using measures such erosion control blankets on slopes, temporary sediment storage basins, and silt fencing (USACE 2011).

This section discusses the potential impacts to drinking water from the construction and/or modification of the structural measures shown below.

- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)
- Construct water temperature control tower (#105)
- Structural improvements to reduce TDG (#174)
- Restore upstream and downstream passage at drop structures (#639)
- Construct AFF (#722)
- Provide Pacific lamprey passage and infrastructure (#52)
- Construct structural downstream fish passage (#392)
- Operation, Maintenance, Repair, Replacement and Rehabilitation

**<u>Foster fish ladder temperature improvement (#479); Construct WTC towers (#105); Structural improvements to reduce total dissolved gas (#174)</u>**

Construction activities associated with the Foster fish ladder temperature improvement (#479), construction of WTC towers (#105), and structural improvements to reduce TDG (#174) would have adverse negligible effects in the medium term as measures to prevent erosion and sedimentation would be implemented during construction.

Foster fish ladder temperature improvement (#479) would provide enhanced temperature control and normative (i.e., the standards of temperature needed for fish passage) water temperatures downstream for fish passage during regular operations. A new Forebay Warm Water Supply (FWWS) would allow warmer surface from the Foster forebay to be released downstream, resulting in blending with cooler surface water. The release of warmer water at the surface would have beneficial effects on the formation of HABs and public health and safety as it would allow mixing of the surface waters. Inadequate mixing and lack of rainfall during summer months can lead to stagnant waters and stratification of the reservoir (i.e., the formation of thermal layers). Temporal stratification has adverse effects on water quality, including the trapping of nutrients in the water column which can lead to eutrophication (see Section 3.17.1 Affected Environment which discusses eutrophication). Therefore, the enhanced temperature controls that reduce stratification would be beneficial towards reducing HABs formation within the water column and on the water surface of the reservoir. The effects would be beneficial, minor, short and long term recurring during reservoir releases.

Construction of WTC towers (#105) would have long-term beneficial effects on the prevention of HABs. During the conservation months, there is a higher potential for HABs formation due to the inflow of water from the watershed, which carries high concentrations of nutrients. Along with the reduction of outflow from the reservoir, this can lead to the accumulation of nutrients in the reservoir. HABs can form when residence time in the reservoir is long and the flushing rate or outflow from the reservoir is reduced. Also, temperature stratification in the reservoir, where warm waters are usually located at the surface and cooler waters at the bottom, can promote HAB growth (Linkov et al. 2009). Mixing and blending cooler water with warmer surface water can reduce HAB accumulation having a beneficial effect; however, this technique may not be possible on a large scale within the entire reservoir. Reservoir releases can reduce the accumulation of HABs and dilute toxins, which can prevent a HABs occurrence. The water temperature control towers would allow blending of warm water with cooler water and would reduce stagnant waters which are conducive to HAB growth. The flowing water and turbulence within the reservoir would also inhibit HAB growth. Also, the release of water from the reservoir would discharge concentrated nutrients from the middle to lower portions of the reservoir downstream, further reducing HAB growth within the reservoir itself. However, water from the middle to lower portions of the reservoir can have high concentrations of nutrients and metals from the sediment accumulated at the bottom of the reservoir (Kennedy and Gaugush, 1988). The discharged concentrated nutrients from the middle to lower portions of the reservoir could also cause adverse impacts, leading to the buildup of nutrients downstream which could cause HABs formation. Therefore effects would be beneficial and adverse minor, short and long term recurring during reservoir releases.

Structural improvements to reduce TDG (#174) would have beneficial effects on HABs and public health and safety. When water flows over the spillway air dissolves into the water which cause nitrogen to increase dramatically (EPA 1971). Excess nutrients can lead to HAB occurrence through the process of eutrophication (or the enrichment of algae growth due to excess nutrients; see Affected Environment Section 3.17.1). Therefore, reducing TDG would be beneficial towards the prevention of HABs. The reduction of TDG is accomplished by discharge through the powerhouse to reduce the TDG from spillways and outlets, or by distributing flows through as many spillways as possible. The reduction in TDG would improve water quality as it would reduce the amount of nitrogen in downstream waters. The effects would be beneficial minor, short and long term permanent in duration.

**Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)**

Maintaining revetments using nature-based engineering or altering revetments for aquatic ecosystem restoration (#9) would occur basin-wide. Increases in sedimentation associated with construction and maintenance work could contribute to a HAB event, which would affect public health and safety. However, measures to prevent erosion and sedimentation would be implemented during construction. Therefore, the effects would be adverse negligible, short term during construction. In the long term, the maintenance revetments would have no effects on public health and safety – HABs.

**Restore upstream and downstream passage at drop structures (#639), construct AFF (#722), provide Pacific lamprey passage and infrastructure (#52), construct structural downstream fish passage infrastructure (#392)**

These four fish infrastructure measures would have similar effects. The construction effects would be adverse and negligible as measures to prevent erosion and sedimentation would be implemented. The effects of restoring upstream and downstream passage at drop structures (#639) would be short term in duration. For the construction of AFFs (#722), providing Pacific lamprey passage and infrastructure (#52), and constructing structural downstream fish passage infrastructure (#392), construction effects would be medium term in duration.

The construction of structural downstream fish passage infrastructure (#392) would have beneficial effects on the prevention of HABs as minimum flows would be required to allow fish passage operations. The use of Floating Screen Structures (FSS) would require minimum flow rates (see the flow required minimum flow rates in Table 2-10), and modification of the fish weir would require flow rates of 600 cfs per year. Continual flow of water would reduce stagnancy of waters near the location of the fish passage structures, thus preventing HAB growth locally. The effects would be beneficial, minor, short and long term recurring. The construction of AFFs (#722) would have no effects on the formation of HABs in the long term as effluent discharge from the flushing of fish facilities would be required to meet water quality permit requirements (see the discussion under 3.17.5.4.1 under OMRRR). Restoring upstream and downstream passage at drop structure (#639) and the construction of fish passage infrastructure for Pacific lamprey (#52) would reduce stagnancy of waters near the location of the fish passage structures due to continual flow of water, thus preventing HAB growth locally. The effects would be beneficial, minor, short and long term recurring.

##### *3.17.5.3.2 Implementation of Water Management Measures*

This section discusses the potential impacts to EJ communities from the implementation of the following water management measures:

- Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166)
- Augment instream flows by using the inactive pool (#718)
- Augment instream flows by using the power pool (#304)
- Integrated temperature and habitat flow regime (#30a)
- Refined integrated temperature and habitat flow regime (#30b)
- Deeper fall reservoir drawdowns for fish passage (#40)
- Spring reservoir drawdown for downstream fish passage (#720)
- Pass water over spillway in spring for fish passage (#714)
- Near-term Operations Measure
- Fall Creek Drawdown
- Existing Operations Continued Forward

**Use regulating outlets (ROs) to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166); Deeper fall reservoir drawdowns for fish passage (#40); Spring reservoir drawdown for downstream fish passage (#720)**

Using ROs to discharge cold water (#166) would have adverse effects on downstream waters which may be used for drinking water. Discharging cold water would allow the reservoir to ‘turnover’ as described in Section 2.2.2.2. However, the discharge of the cold water from the reservoir would release concentrated nutrients upward due to mixing in the water column from the lower depths of the reservoir where sediment and heavy metals accumulate in low oxygen conditions; the decreased quality of water would also be released downstream reducing the quality of water used for drinking. The effects would be adverse, minor, short and long term recurring when reservoir releases occur.

The reservoir drawdowns would have adverse effects on water quality downstream. Nutrients at the bottom of the reservoir flow would be released downstream, reducing water quality and would have effects similar to using ROs to discharge cold water (#166). The effects would be adverse minor, short and long term recurring in the fall and spring.

**Use spillway for summer surface spill (#721); Pass water over spillway in spring for fish passage (#714)**

Using the spillway for summer surface spill (#721) would have minor, beneficial effects to HABs and public health and safety as it would promote mixing of the reservoirs' surface waters which could reduce stratification locally as described for Foster fish ladder temperature improvement (#479) in Section 3.17.5.3.1. The release of warmer water at the surface would have adverse minor, short- and long-term recurring effects during summer spillway releases.

Spring spillway fish passage (#714) would have the same effects as using the spillway for summer surface spill (#721). The release of water from the surface spillway reduces stratification which would have beneficial and minor, short- and long-term recurring effects during spillway releases.

**Augment instream flows by using the inactive pool (#718); Augment instream flows by using the power pool (#304); Reduce minimum flows to Congressionally authorized minimum flow requirements (#723)**

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse effects on HABs and public health and safety as water from the deeper portions of the pool would be released (see Figure 2 Reservoir storage layers in the Glossary). The downstream waters would be adversely affected by deep reservoir releases, due to the influx of concentrated nutrients resulting in reduced quality of water which could lead to HABs. The effects would be adverse, minor, short and long term recurring during reservoir releases.

Minimizing stream flows to Congressionally authorized minimum flows (#723) would have beneficial effects for HABs. Reducing outflows to the Congressionally authorized minimum flows would allow reservoirs to capture more spring runoff rather than releasing it. The minimum flows would maintain water quality standards by preventing stagnant water. Flowing water and turbulence reduce the potential for HAB growth. Effects would be beneficial minor, short and long term recurring when flows are reduced.

**Integrated temperature and habitat flow regime (#30a); Refined integrated temperature and habitat flow regime (#30b)**

Integrated temperature and habitat flow regime (#30a) and refined integrated temperature and habitat flow regime (#30b) would also have similar beneficial effects on reducing HABs formation and public health and safety. Measure #30b has slight changes to the mainstem and tributary flows than measure #30a. The adaptive fish flows would prevent stagnancy of the water, thereby maintaining water quality. The effects would be beneficial, minor, short and long term recurring annually. Operation of the WVS follows a four-season cycle, winter flood risk management (FRM) season and summer conservation season with spring refill and fall release periods as described in Section 1.10.

**Near-term Operations Measure**

The Near-term Operations Measure are a suite of 16 operations described in Chapter 2. The operations measures are analyzed by grouping measures by where water is released from the dam, either through the regulating outlets or surface spillway releases. The depth in the reservoir from where water is released would have different effects on HABs occurrence. Water released from the surface spillway would have less adverse and more beneficial effects than water released from the lower depths of the reservoir such as from the regulating outlets which is explained below.

***RO Release***

- Nighttime RO prioritization for improved downstream fish passage at Detroit Dam;
- Deep drawdown and RO prioritization for improved downstream fish passage at Cougar Dam;
- Delayed reservoir refill and RO prioritization for improved downstream fish passage at Cougar Dam;
- Nighttime RO prioritization for improved downstream fish passage (downstream fish passage) at Hills Creek Dam;
- Deep drawdown and RO prioritization for improved downstream fish passage at Lookout Point Dam;
- Extended deep drawdown and RO prioritization for improved downstream fish passage at Falls Creek Dam and delayed reservoir refill and RO prioritization for improved downstream fish passage at Falls Creek Dam

Using ROs to discharge cold water would have adverse effects on downstream waters where HABs formation could occur. Discharging cold water would allow the reservoir to ‘turnover’ as described in Section 2.2.2.2. However, the discharge from the ROs of the reservoir would also release concentrated nutrients upward due to mixing in the water column from the lower depths of the reservoir where sediment and heavy metals accumulate in low oxygen conditions. The decreased quality of water would also be released downstream leading to the potential for a HABs event. The effects on HABs formation and public health and safety would be adverse minor, short and long term and recurring during reservoir releases.

***Spillway release***

- Spread spill across spillways to reduce downstream TDG exceedances at Big Cliff Dam;
- Utilize spillway for improved downstream fish passage in the spring; perform spill operation until 01 May or for 30 days, whichever is longer at Green Peter Dam;

- Delay refill and utilize spillway in the spring for improved downstream fish passage; use the fish weir in the summer for improved downstream temperature management and upstream fish migration/passage at Green Peter Dam;
- Utilize the spillway for improved downstream fish passage in the fall at Foster Dam

Using the spillway would have beneficial effects to HABs and public health and safety as it would promote mixing of the reservoirs' surface waters which could reduce stratification locally as described for the Foster fish ladder temperature improvement measure (#479) in Section 3.17.5.3.1 above. The release of warmer water at the surface would have beneficial minor effects in the short and long term recurring during summer spillway releases.

***Combined RO and Spillway release***

- Spring downstream fish passage and operational downstream temperature management at Detroit dam
- Utilize spillway for improved downstream fish passage in the spring at Lookout Point Dam; RO use in the fall for downstream temperature management at Lookout Point Dam

These measures use a combination of using both the RO and the spillway which would result in adverse and beneficial, minor, large and long-term recurring effects similar to the effects analyzed under the RO release and Spillway release measures above. The effects of downstream temperature management at Detroit Dam would be similar to the integrated temperature and habitat flow regime (#30a); the effects would be beneficial, minor, short and long term recurring.

**<u>Existing Operations Continued Forward</u>**

***Fall Creek Drawdown***

Reservoir releases or drawdowns can reduce the accumulation of HABs and dilute toxins within the reservoir itself, which can prevent a HABs occurrence. However, nutrients could be released downstream, causing HABs to occur downstream. The drawdowns would continue to have adverse effects on downstream reaches under the NAA, but would be beneficial for preventing HABs in the reservoir. Overall effects would be beneficial and adverse minor, short and long term recurring throughout the year as the pool volumes are adjusted.

***Continued Operation of Existing Adult Fish Facilities***

O&M activities associated with existing AFFs would continue to have little or no effects on public health and safety – HABs. Water from maintenance for flushing of fish facilities or effluent water may be high in pollutants. However, hatcheries are required to meet water quality standards for their waste/effluent water (EPA 2021j). These discharges from fish facilities are required to meet the NPDES permit requirements. Thresholds are set for total suspended solids (TSS), settleable solids, temperature, and pH and must not be exceeded during routine monitoring. Thus, any effects would be adverse, negligible, short and long term recurring during regular maintenance.

***Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRRR)***

Routine and non-routine maintenance activities, repair, replacement and rehabilitation under the NAA overall would have adverse minor, short term effects on public health and safety as sediment-laden discharges from construction activities could affect drinking water quality. However, construction activities would require measures to prevent erosion and sedimentation to be implemented during construction. Effects would be adverse minor, small in the vicinity of the maintenance site, medium and long term recurring.

### *3.17.5.4 No Action Alternative*

This analysis addresses the effects if the existing O&M of the WVS system would continue. The current operations which could have either beneficial or adverse effects on the growth of HABs and public health and safety.

This analysis addresses the effects if the existing O&M of the WVS system would continue. The current operations which could have either beneficial or adverse effects on the drinking water and public health and safety. Effects of temperature control and TDG reduction measures would be beneficial and adverse minor, large, short and long term recurring. The effects of maintaining flow targets would have beneficial, minor, large effects in the short and long term recurring and augmenting flows would have adverse minor, small, short- and long-term recurring effects. Passing water over the spillway has beneficial, minor, large, short- and long-term recurring effects. For the existing operations continued forward, the effects would be beneficial and adverse minor, large, short and long term recurring due to the Fall Creek drawdown; adverse, negligible, small, short and long term recurring for continued operation of adult fish facilities; adverse, negligible, small, short and long term recurring for routine maintenance; and adverse negligible, small, effects in the short- long-term recurring for routine and non-routine, and medium- and long term recurring for major maintenance.

The NAA includes water quality, flow, and upstream and downstream passage operations. Water quality operations include using the spillway to release warm surface water and manage downstream temperatures at Foster and Detroit; strategically using outlets to meet temperature targets (when possible) at Fall Creek; operating the Cougar WTC tower to manage downstream temperatures; spreading spill across the Dexter and Big Cliff spillways to reduce TDG; and discharging water through the powerhouse at power-producing dams to reduce TDG.

These water quality operations to control temperature and reduce TDG would continue to be beneficial and adverse for drinking water. The release of warmer water at the surface would have beneficial effects on the prevention of HABs of the reservoir as it would allow mixing of the surface waters and would reduce stratification of the reservoir as discussed under the Foster fish ladder temperature improvement (#479) in Section 3.19.5.3.1. Reducing TDG would also be beneficial towards the prevention of HABs as it would reduce the amount of nitrogen in the water as discussed under the construction of WTC towers (#479) in Section 3.19.5.3.1. However, the reduction of TDG is accomplished by discharge through the powerhouse to reduce the TDG from spillways and outlets, or by distributing flows through as many spillways as possible which could release sediment and nutrients downstream. Therefore, effects of temperature control and TDG reduction measures would be beneficial and adverse minor, large, short and long term recurring.

Flow operations include meeting the 2008 BiOp targets basin-wide and augmenting flows using the inactive or power pool at Green Peter. Maintaining operational flow targets for fish and wildlife conservation require reservoir releases which are beneficial to the prevention of HAB accumulation because they reduce residence time and allow blending of cooler water with warm water. Reservoir releases would also continue to dilute concentrated nutrients in the reservoir. Therefore, maintaining operational flow targets for fish and wildlife conservation would continue to have beneficial, minor, large effects in the short and long term recurring. As discussed above in Sections 3.19.6.3.2, augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse, minor, large effects in the short and long term recurring during reservoir releases.

Fish passage operations include passing fish over the Foster spillway and through the lowest RO at Fall Creek (Fall Creek drawdown). Passing water over the spillway has beneficial, minor, large, short- and long- term recurring effects. The Fall Creek drawdown is discussed below under existing operations continued forward.

#### *3.17.5.4.1 Existing operations continued forward*

**Fall Creek Drawdown**

As discussed in Section 3.17.5.3.1, reservoir releases or drawdowns can reduce the accumulation of HABs and dilute toxins within the reservoir itself, which can prevent a HABs occurrence. However, nutrients could be released downstream, causing HABs to occur downstream. The drawdowns would continue to have adverse effects on downstream reaches under the NAA, but would be beneficial for preventing HABs within the reservoir. Effects would be beneficial and adverse minor, large, short and long term recurring throughout the year as the pool volumes are adjusted.

**Continued Operation of Existing Adult Fish Facilities**

O&M activities associated with existing AFFs would continue to have little or no effects on public health and safety – HABs. Discharges from fish facilities are required to meet the water quality standards for effluent as discussed previously in Section 3.17.5.3.2. Thus, any effects would be adverse, negligible, small in extent localized to the area of discharge, short and long term recurring.

**<u>Operation, Maintenance, Repair, Replacement and Rehabilitation</u>**

Scheduled/routine maintenance and non-routine maintenance activities would be adverse as effects of sediment-laden discharges from construction activities could affect drinking water quality. Effects would be negligible in magnitude as measures to prevent erosion and sedimentation would be implemented during construction. Therefore, effects are adverse and negligible in the short term. Similarly, effects of major maintenance and repairs would be adverse and negligible however the duration of major maintenance is medium term and long term recurring.

##### *3.17.5.4.2 Climate Change*

The impact on public health and safety – HABs due to environmental conditions which may change as a result of climate change is analyzed in this section. The climate change projected trend information is based on the hydrologic trends discussed in Appendix F.

Increased temperatures due to climate change can cause inflow, stored water, and reservoir release water to be warmer. Warmer water temperatures can increase stratification of the reservoir, restricting the ability of the reservoir to mix and move oxygen and water vertically, which is a favorable condition for HAB growth as well as promoting the toxin producing cyanobacteria to grow faster (EPA 2013a).

Increased precipitation and streamflow events have the potential to draw more nutrient laden sediment into the reservoirs, leading to increased frequency of flood risk storage for prolonged periods. This has the potential to increase nutrients within the reservoirs, leading to greater HABs occurrences. Effects of increased precipitation would be adverse moderate due to the potential for unsafe conditions due to increased occurrence of HABs events, large affecting the reservoir and downstream reaches, and long-term permanent and intermittent on public health and safety.

Prolonged periods between rainfall events (or drought periods) could cause decreases in streamflow, leading to less water entering the reservoirs. The stream inflow to the reservoir allows warmer water to blend and cool down. With less cool water blending with the warm water in reservoir, this could lead to an increase in HABs. Decreased baseflows would have adverse moderate effects due to the potential for unsafe conditions due to increased occurrence of HABs events, large, and long-term permanent and intermittent effects basin wide on public health and safety.

Warmer temperatures from climate change could also provide favorable conditions for the propagation of HABs. which can discolor, cloud, or cover the water's surface and affect drinking water. Wildfire ash can land in reservoirs, streams, and rivers, increasing turbidity and adversely affecting the water quality of those water bodies which communities rely on for drinking water.

#### *3.17.5.5 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Under Alternative 1, fish passage would be improved through storage-focused measures by maximizing refill volumes of conservation pools and tapping into the power pool, augmenting flow to the congressionally authorized minimum flows. This would increase the likelihood of refilling to the maximum conservation pool levels. The effects of the measures proposed under Alternative 1 are analyzed in this section. Effects are the similar to the effects described under the Discussion of Effects by Measure(s).

Effects are the similar to the effects described under the Discussion of Effects by Measure(s). Alternative 1 effects would be adverse negligible, small, in the short term or medium term for the construction and/or modification of any structural measures which include maintenance or alteration of revetments (#9); the maintenance of existing and new fish release sites (#726); Operation, maintenance, repair, replacement and rehabilitation; Foster fish ladder temperature improvement (#479); construction of WTC towers (#105); structural improvements to reduce total dissolved gas (#174); restoring upstream and downstream passage at drop structures (#639); construction of AFFs (#722); providing Pacific lamprey passage and infrastructure (#52); and construction structural fish passage infrastructure (#392).

In the long term, the maintenance or alteration of revetments (#9) would have no effects on HABs formation and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects. Foster fish ladder temperature improvement (#479), the construction of WTC towers (#105), and structural improvements to reduce total dissolved gas (#174) would have beneficial and/or adverse, minor, large, short and long-term recurring effects. The effects of structural improvements to reduce total dissolved gas (#174) would be beneficial, minor, large in the short and long term.

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse minor, large, short- and long-term recurring effects. Effects on reducing minimum flows to Congressionally authorized minimum flow requirements (#723) basin-wide would have beneficial minor, large, short and long term recurring when flows are reduced.

Restoring upstream and downstream passage at drop structure (#639), the construction of fish passage infrastructure (#392) and provide Pacific lamprey passage and infrastructure (#52) would be beneficial, minor, small, short and long term recurring. The construction of AFFs (#722) and the continued operation of existing adult fish facilities would be negligible, small, in the short and long term recurring.

It should be noted that for each these measures, water treatment at the drinking water facility would mitigate some of the effects of low-quality water. Without treatment, water quality effects would be a higher magnitude, duration or extent.

###### *3.17.5.5.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) basin-wide; Operation, maintenance, repair, replacement and rehabilitation*

Maintenance and alteration of revetments is a measure common to all alternatives and would occur basin-wide. The effects would be adverse negligible, small, and short term. In the long term, the revetments would have no effects on HABs formation and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects.

Construction effects of these measures would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

###### *3.17.5.5.2 Foster Fish Ladder Temperature Improvement (#479); Construct WTC Towers (#105) at Detroit, Green Peter and Lookout Point dams; Structural improvements to reduce total dissolved gas (#174) at Cougar, Detroit, Dexter, Foster, Green Peter, and Lookout Point dams;*

Foster fish ladder temperature improvement (#479) would have beneficial effects. A new Forebay Warm Water Supply would allow warmer surface from the Foster forebay to be released downstream, resulting in blending with cooler surface water. The effects would be beneficial, minor, large, short and long term recurring during reservoir releases.

The construction of WTC towers (#105) would have beneficial and adverse minor, large, short and long term recurring when reservoir releases occur.

Structural improvements to reduce total dissolved gas (#174) would have beneficial minor, large effects. The effects would be short and long term and permanent in duration.

Construction effects of these measures would be adverse negligible, small in the medium term as measures to prevent erosion and sedimentation would be implemented during construction.

###### *3.17.5.5.3 Augment instream flows by using the inactive pool (#718) at Blue River, Cottage Grove, Dorena, and Falls Creek dams; Augment instream flows by using the power pool (#304) Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point dams; Reduce minimum flows to Congressionally authorized minimum flow requirements (#723) basin-wide; Fall Creek drawdown*

Augmenting instream flows by using the inactive pool (#718), augmenting instream flows by using the power pool (#304), and the Fall Creek drawdown would have adverse effects on HABs and public health and safety as water from the deeper portions of the pool would be released. The effects would be adverse minor, large, short and long term recurring during reservoir releases.

Reducing minimum flows to Congressional authorized minimum flow requirements (#723) would be beneficial minor, large, short and long term recurring when flows are reduced.

##### *3.17.5.5.4 Restore upstream and downstream passage at drop structures at Fern Ridge Dam (#639); construct AFFs at Green Peter Dam (#722); provide Pacific lamprey passage and infrastructure at Fern Ridge and Green Peter dams (#52); and construct structural fish passage infrastructure at (#392) Detroit, Foster, Green Peter, Lookout Point, Big Cliff, and Dexter dams; Continued operation of existing adult fish facilities*

Restoring upstream and downstream passage at drop structure (#639), providing Pacific lamprey passage and infrastructure (#52), and the construction of fish passage infrastructure (#392) would reduce stagnancy of waters near the location of the fish passage structures due to continual flow of water, thus preventing HAB growth locally. The effects would be beneficial, minor, small, short and long term recurring. The construction of AFFs (#722) and the continued operation of existing adult fish facilities would be adverse, negligible, small, in the short and long term recurring.

Construction effects of these measures would be adverse negligible, small, in the short or medium term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.17.5.5.5 Climate Change*

Alternative 1 would combine storage-focused measures in order to improve fish passage. The measures in Alternative 1 would improve reservoir storage and improve water quality by reducing TDG and normalizing temperatures. Therefore, the effects of climate change on drinking water would be less severe under Alternative 1 than any other alternative, including the NAA. Climate change in combination with the measures under Alternative 1 would have adverse, moderate, large, long-term intermittent and /or permanent effects to HABs.

#### ***3.17.5.6 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative***

Under Alternative 2A, integrated temperature and habitat flow regimes would be utilized as well as using the power pool to augment flows. Structural and operational measures are proposed to address water quality as well as the Near-Term Operations Measure(s) as discussed under Section 2.2.5. The effects of the measures proposed under Alternative 2A are analyzed in this section. Effects are the similar to the effects described under the Discussion of Effects by Measure(s).

Alternative 2A effects would be adverse negligible, small, in the short term or medium term for the construction and/or modification of any structural measures which include maintenance or alteration of revetments (#9); Foster fish ladder temperature improvement (#479); construction of WTC towers (#105); deeper fall reservoir drawdowns for fish passage (#40); construction of AFFs (#722); providing Pacific lamprey passage and infrastructure (#52); and construction structural fish passage infrastructure (#392).

In the long term, the maintenance or alteration of revetments (#9) would have no effects on HABs formation and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects. Foster fish ladder temperature improvement (#479) and the construction of WTC towers (#105) would have beneficial and or adverse, minor, large, short and long-term recurring effects.

Using ROs to discharge cold water (#166), deeper fall reservoir drawdowns for fish passage (#40), and the Fall Creek drawdown would have adverse minor, large, short- and long-term recurring effects. Using the spillway for surface spill in summer (#721) and spring spillway fish passage (#714) would have beneficial, minor, large, short- and long-term recurring effects. Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse minor, large, short- and long-term recurring effects. Integrated temperature and habitat flow regime (#30a) would have beneficial minor, small effects in the short and long term recurring annually.

Providing Pacific lamprey passage and infrastructure (#52) and the construction of fish passage infrastructure (#392) and would have beneficial, minor, small effects in the short and long term recurring. The effects of the construction of AFFs (#722) and the continued operation of existing adult fish facilities would be negligible, small, in the short and long term recurring.

It should be noted that for each these measures, water treatment at the drinking water facility would mitigate some of the effects of low-quality water. Without treatment, water quality effects would be a higher magnitude, duration or extent.

##### *3.17.5.6.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) basin-wide; Operation, maintenance, repair, replacement and rehabilitation*

Maintenance and alteration of revetments is a measure common to all alternatives and would occur basin-wide. The effects would be adverse negligible, small, and short term. In the long term, the revetments would have no effects on HABs formation and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects.

Construction effects of these measures would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.17.5.6.2 Foster Fish Ladder Temperature Improvement (#479); Construct WTC tower (#105) at Detroit Dam*

Foster fish ladder temperature improvement (#479) would have beneficial effects. A new Forebay Warm Water Supply would allow warmer surface from the Foster forebay to be released downstream, resulting in blending with cooler surface water. The effects would be beneficial, minor, large, short and long term recurring during reservoir releases.

The construction of WTC towers (#105) would have beneficial and adverse minor, large, short and long term recurring when reservoir releases occur.

Construction effects of these measures would be adverse negligible, small in the medium term as measures to prevent erosion and sedimentation would be implemented during construction.

*3.17.5.6.3 Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) at Green Peter Dam; Deeper fall reservoir drawdowns for fish passage (#40) at Green Peter Dam; Fall Creek drawdown*

Using ROs to discharge cold water (#166), deeper fall reservoir drawdowns for fish passage (#40), and the Fall Creek drawdown would have adverse effects on downstream waters where HABs formation could occur. The effects would be adverse minor, large, short and long term recurring during reservoir releases.

Construction effects of associated with the deeper fall reservoir drawdowns for fish passage (#40) would be adverse negligible, small in the medium term as measures to prevent erosion and sedimentation would be implemented during construction.

*3.17.5.6.4 Use spillway for surface spill in summer (#721) at Green Peter Dam; Pass water over spillway in spring for fish passage (#714) at Green Peter Dam*

Use spillway for surface spill in summer (#721) and spring spillway fish passage (#714) would have beneficial effects on HABs formation. The effects would be beneficial, minor, large, short and long term recurring during summer spillway releases.

*3.17.5.6.5 Augment instream flows by using the inactive pool (#718) at Blue River and Falls Creek dams; Augment instream flows by using the power pool (#304) at Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point dams*

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse effects on HABs and public health and safety as water from the deeper portions of the pool would be released. The effects would be adverse minor, large, short and long term recurring during reservoir releases.

*3.17.5.6.6 Integrated temperature and habitat flow regime (#30a) basin-wide*

Integrated temperature and habitat flow regime (#30a) would have beneficial effects on reducing HABs formation and public health and safety. The effects would be beneficial, minor, small affecting the downstream waters only, in the short and long term recurring annually.

##### *3.17.5.6.7 Construct adult fish facilities (#722) at Green Peter Dam; Pacific lamprey passage and infrastructure at Green Peter Dam (#52); construct structural downstream fish passage (#392) at Cougar, Detroit, Foster, Lookout Point, Big Cliff, and Dexter dams; Continued operation of existing adult fish facilities*

Providing Pacific lamprey passage and infrastructure (#52) and the construction of fish passage infrastructure (#392) and would reduce stagnancy of waters near the location of the fish passage structures due to continual flow of water, thus preventing HAB growth locally. The effects would be beneficial, minor, small, short and long term recurring. The construction of AFFs (#722) and the continued operation of existing adult fish facilities would be adverse negligible, small, in the short and long term recurring.

Construction effects of these measures would be adverse negligible, small, in the short or medium term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.17.5.6.8 Near-term Operations Measures*

The effects of the Near-term Operations Measures are analyzed under Section 3.17.2.3.2. They are a suite of operations measures in which the impacts were analyzed by grouping measures which utilize the ROs or releasing water via the spillway. For both approaches the impacts would result in either adverse and/or beneficial, minor, large, short and long-term recurring effects.

##### *3.17.5.6.9 Climate Change*

Alternative 2A would integrate water management flexibility and ESA-listed fish measures (using structural downstream passage at Cougar Dam). The measures in Alternative 2A would improve water quality by reducing TDG and normalizing temperatures. It would also provide fish passage. However, it would not improve reservoir storage like Alternative 1. In general, climate change would exacerbate effects from deep drawdowns: as temperatures increase and snowpacks decline, reservoirs may struggle to reach their conservation pool elevations over time, which would directly affect drinking water. Climate change in combination with the measures under Alternative 2A would have adverse, moderate, large, long-term intermittent and /or permanent effects to HABs.

#### ***3.17.5.7 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative***

Under Alternative 2B, the effects to public health and safety - HABs would be the same as those described under Alternative 2A. The difference is that the downstream passage measure at Cougar Dam is changed from a structural fish passage structure under 2A to changing of operations to a deep fall and spring drawdown with the construction of a diversion tunnel under 2B. The Near-Term Operations Measure(s) are also proposed under this alternative. The effects of the measures proposed under Alternative 2B are analyzed in this section. Effects are the similar to the effects described under the Discussion of Effects by Measure(s).

Alternative 2B effects would be adverse negligible, small, in the short term or medium term for the construction and/or modification of any structural measures which include maintenance or alteration of revetments (#9); Foster fish ladder temperature improvement (#479); construction of WTC towers (#105); deeper fall reservoir drawdowns for fish passage (#40)construction of AFFs (#722); providing Pacific lamprey passage and infrastructure (#52); and construction structural fish passage infrastructure (#392).

In the long term, the maintenance or alteration of revetments (#9) would have no effects on HABs formation and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects. Foster fish ladder temperature improvement (#479) and the construction of WTC towers (#105) would have beneficial and or adverse, minor, large, short and long-term recurring effects.

Using ROs to discharge cold water (#166), deeper fall reservoir drawdowns for fish passage (#40), spring reservoir drawdown for downstream fish passage (#720); and the Fall Creek drawdown would have adverse minor, large, short- and long-term recurring effects. Using the spillway for surface spill in summer (#721) and spring spillway fish passage (#714) would have beneficial, minor, large, short- and long-term recurring effects. Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse minor, large, short- and long-term recurring effects. Integrated temperature and habitat flow regime (#30a) would have beneficial minor, small effects in the short and long term recurring annually.

Providing Pacific lamprey passage and infrastructure (#52) and the construction of fish passage infrastructure (#392) and would have beneficial, minor, small effects in the short and long term recurring. The effects of the construction of AFFs (#722) and the continued operation of existing adult fish facilities would be negligible, small, in the short and long term recurring.

It should be noted that for each these measures, water treatment at the drinking water facility would mitigate some of the effects of low-quality water. Without treatment, water quality effects would be a higher magnitude, duration or extent.

###### *3.17.5.7.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) basin-wide; Operation, maintenance, repair, replacement and rehabilitation*

Maintenance and alteration of revetments is a measure common to all alternatives and would occur basin-wide. The effects would be adverse negligible, small, and short term. In the long term, the revetments would have no effects on HABs formation and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects.

Construction effects of these measures would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.17.5.7.2 Foster Fish Ladder Temperature Improvement (#479); Construct WTC tower (#105) at Detroit Dam*

Foster fish ladder temperature improvement (#479) would have beneficial effects. A new Forebay Warm Water Supply would allow warmer surface from the Foster forebay to be released downstream, resulting in blending with cooler surface water. The effects would be beneficial, minor, large, short and long term recurring during reservoir releases.

The construction of WTC towers (#105) would have beneficial and adverse minor, large, short and long term recurring when reservoir releases occur.

##### *3.17.5.7.3 Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) at Green Peter Dam; Deeper fall reservoir drawdowns for fish passage (#40) at Cougar, and Green Peter dams and spring reservoir drawdown for downstream fish passage (#720) at Cougar Dam; Fall Creek drawdown*

Using ROs to discharge cold water (#166), deeper fall reservoir drawdowns for fish passage (#40), spring reservoir drawdown for downstream fish passage (#720), and the Fall Creek drawdown would have adverse effects on downstream waters where HABs formation could occur. The effects would be adverse minor, large, short and long term recurring during reservoir releases.

Construction effects of associated with the deeper fall reservoir drawdowns for fish passage (#40) would be adverse negligible, small in the medium term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.17.5.7.4 Use spillway for surface spill in summer (#721) at Green Peter Dam; Pass water over spillway in spring for fish passage (#714) at Green Peter Dam*

Use spillway for surface spill in summer (#721) and spring spillway fish passage (#714) would have beneficial effects on HABs formation. The effects would be beneficial, minor, large, short and long term recurring during summer spillway releases.

##### *3.17.5.7.5 Augment instream flows by using the inactive pool (#718) at Blue River and Falls Creek dams; Augment instream flows by using the power pool (#304) at Detroit, Green Peter, Hills Creek, and Lookout Point dams*

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse effects on HABs and public health and safety as water from the deeper portions of the pool would be released. The effects would be minor, large, short and long term recurring during reservoir releases.

##### *3.17.5.7.6 Integrated temperature and habitat flow regime (#30a) basin-wide*

Integrated temperature and habitat flow regime (#30a) would have beneficial effects on reducing HABs formation and public health and safety. The effects would be beneficial, minor, small affecting the downstream waters only, in the short and long term recurring annually.

##### *3.17.5.7.7 Construct AFF (#722) at Green Peter Dam; Pacific lamprey passage and infrastructure (#52) at Green Peter Dam; construct structural downstream fish passage (#392) at Detroit, Foster, Lookout Point, Big Cliff, and Dexter dams; Continued operation of existing adult fish facilities*

Providing Pacific lamprey passage and infrastructure (#52) and the construction of fish passage infrastructure (#392) and would reduce stagnancy of waters near the location of the fish passage structures due to continual flow of water, thus preventing HAB growth locally. The effects would be beneficial, minor, small, short and long term recurring. The construction of AFFs (#722) and the continued operation of existing adult fish facilities would be negligible, small, in the short and long term recurring.

Construction effects of these measures would be adverse negligible, small, in the short or medium term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.17.5.7.8 Near-term Operations Measures*

The effects of the Near-term Operations Measures are analyzed under Section 3.17.2.3.2. They are a suite of operations measures in which the impacts were analyzed by grouping measures which utilize the ROs or releasing water via the spillway. For both approaches the impacts would result in either adverse and/or beneficial, minor, large, short and long-term recurring effects.

##### *3.17.5.7.9 Climate Change*

Alternative 2B would integrate water management flexibility and ESA-listed fish measures (using a deep drawdown to Cougar Dam’s DT). Climate change is expected to adversely affect water quantity and air and water quality. The measures in Alternative 2B would improve water quality by reducing TDG and normalizing temperatures. It would also provide fish passage. However, it would not improve reservoir storage like Alternative 1. However overall, the effects would be the same as under Alternative 2A; climate change in combination with the measures under Alternative 2B would have adverse, moderate, large, long-term intermittent and/or permanent effects to HABs.

#### ***3.17.5.8 Alternative 3A – Operations-Focused Fish Passage Alternative***

Under Alternative 3A, improved fish passage is proposed through the modifying of operations instead rather than focusing on storage (Alternative 1) or structural measures (Alternative 4). The Near-Term Operations Measure(s) are also proposed under this alternative. The effects of the measures proposed under Alternative 3A are analyzed in this section. Effects are the similar to the effects described under the Discussion of Effects by Measure(s).

Alternative 3A effects would be adverse negligible, small, in the short term or medium term for the construction and/or modification of any structural measures which include maintenance or alteration of revetments (#9); deeper fall reservoir drawdowns for fish passage (#40) construction of AFFs (#722); and providing Pacific lamprey passage and infrastructure (#52). In the long term, the maintenance or alteration of revetments (#9) would have no effects on HABs formation and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects.

Using ROs to discharge cold water (#166), deeper fall reservoir drawdowns for fish passage (#40), spring reservoir drawdown for downstream fish passage (#720); and the Fall Creek drawdown would have adverse minor, large, short- and long-term recurring effects. Using the spillway for surface spill in summer (#721) and spring spillway fish passage (#714) would have beneficial, minor, large, short- and long-term recurring effects. Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse minor, large, short- and long-term recurring effects. Integrated temperature and habitat flow regime (#30a) would have beneficial minor, small effects in the short and long term recurring annually. Providing Pacific lamprey passage and infrastructure (#52) would be beneficial, minor, small, short and long term recurring. The effects of the construction of AFFs (#722) and the continued operation of existing adult fish facilities would be negligible, small, in the short and long term recurring.

It should be noted that for each these measures, water treatment at the drinking water facility would mitigate some of the effects of low-quality water. Without treatment, water quality effects would be a higher magnitude, duration or extent.

#### *3.17.5.8.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) basin-wide; Operation, maintenance, repair, replacement and rehabilitation*

Maintenance and alteration of revetments is a measure common to all alternatives and would occur basin-wide. The effects would be adverse negligible, small, and short term. In the long term, the revetments would have no effects on HABs formation and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects.

Construction effects of these measures would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

#### *3.17.5.8.2 Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) at Detroit; Green Peter; and Lookout Point dams; Deeper fall reservoir drawdowns for fish passage*

*(#40) at Blue River; Cougar; Detroit; Green Peter; Hills Creek; Lookout Point; Spring reservoir drawdown for downstream fish passage (#720) at Cougar; Detroit; and Lookout Point dams; Fall Creek drawdown*

Using ROs to discharge cold water (#166), deeper fall reservoir drawdowns for fish passage (#40), spring reservoir drawdown for downstream fish passage (#720), and the Fall Creek drawdown would have adverse effects on downstream waters where HABs formation could occur. The effects would be adverse minor, large, short and long term recurring during reservoir releases.

Construction effects of associated with the deeper fall reservoir drawdowns for fish passage (#40) would be adverse negligible, small in the medium term as measures to prevent erosion and sedimentation would be implemented during construction.

*3.17.5.8.3 Use spillway for surface spill in summer (#721) at Blue River; Detroit; Foster; Green Peter; Hills Creek; and Lookout Point dams; Pass water over spillway in spring for fish passage (#714) at Big Cliff, Dexter, Falls Creek, Green Peter, and Hills Creek dams*

Using the spillway for surface spill in summer (#721) and spring spillway fish passage (#714) would have beneficial effects on HABs formation. The effects would be beneficial, minor, large, short and long term recurring during summer spillway releases.

*3.17.5.8.4 Augment instream flows by using the inactive pool (#718) at Blue River, Cottage Grove; Dorena; and Falls Creek dams; Augment instream flows by using the power pool (#304) at Cougar, Detroit, Green Peter; Hills Creek; and Lookout Point dams*

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse effects on HABs and public health and safety as water from the deeper portions of the pool would be released. The effects would be minor, large, short and long term recurring during reservoir releases.

*3.17.5.8.5 Integrated temperature and habitat flow regime (#30a) basin-wide*

Integrated temperature and habitat flow regime (#30a) would have beneficial effects on reducing HABs formation and public health and safety. The effects would be beneficial, minor, small affecting the downstream waters only, in the short and long term recurring annually.

*3.17.5.8.6 Construct adult fish facilities (#722) at Blue River; Green Peter; and Hills Creek dams; Pacific lamprey passage and infrastructure (#52) at Blue River; Green Peter; and Hills Creek dams; Continued operation of existing adult fish facilities*

Providing Pacific lamprey passage and infrastructure (#52) would reduce stagnancy of waters near the location of the fish passage structures due to continual flow of water, thus preventing HAB growth locally. The effects would be beneficial, minor, small, short and long term recurring. The construction of AFFs (#722) and the continued operation of existing adult fish facilities would be negligible, small, in the short and long term recurring.

Construction effects of these measures would be adverse negligible, small, in the short or medium term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.17.5.8.7 Near-term Operations Measures*

The effects of the Near-term Operations Measures are analyzed under Section 3.17.2.3.2. They are a suite of operations measures in which the impacts were analyzed by grouping measures which utilize the ROs or releasing water via the spillway. For both approaches the impacts would result in either adverse and/or beneficial, minor, large, short and long-term recurring effects.

##### *3.17.5.8.8 Climate Change*

Alternative 3A would improve fish passage by using operations-focused measures (using a deep drawdown to Cougars Dam's RO). The measures in Alternative 3A would improve water quality by normalizing temperatures. It would also provide fish passage with numerous deep drawdowns. Alternatives 3A and 3B would include more than twice as many drawdowns as the other alternatives, and Alternative 3A would include the less-deep drawdown to the Cougar RO. Climate change in combination with the measures under Alternative 3A would have adverse, moderate, large, long-term intermittent and/or permanent effects to HABs.

#### *3.17.5.9 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at COU)*

Under Alternative 3B, the effects to public health and safety - HABs would be the same as those described under Alternative 3A. Alternative 3B proposes the slightly different combination of operations for the downstream passage. 3A proposes the drawdown to 10 feet over the top of the Cougar Dam RO for deep fall and spring drawdown measures and 3B proposes drawdown utilizing the diversion tunnel at Cougar. The Near-Term Operations Measure(s) are also proposed under this alternative. The effects of the measures proposed under Alternative 3B are analyzed in this section. Effects are the similar to the effects described under the Discussion of Effects by Measure(s).

Overall, Alternative 3B effects would be similar to Alternatives 1, 2A, 2B, and 3A. Alternative 3A effects would be adverse negligible, small, in the short term or medium term for the construction and/or modification of any structural measures which include maintenance or alteration of revetments (#9); deeper fall reservoir drawdowns for fish passage (#40); construction of AFFs (#722); and providing Pacific lamprey passage and infrastructure (#52). In the long term, the maintenance or alteration of revetments (#9) would have no effects on HABs formation and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects.

Using ROs to discharge cold water (#166), deeper fall reservoir drawdowns for fish passage (#40), spring reservoir drawdown for downstream fish passage (#720); and the Fall Creek drawdown would have adverse minor, large, short- and long-term recurring effects. Using the spillway for surface spill in summer (#721) and spring spillway fish passage (#714) would have beneficial, minor, large, short- and long-term recurring effects. Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse minor, large, short- and long-term recurring effects. Integrated temperature and habitat flow regime (#30a) would have beneficial minor, small effects in the short and long term recurring annually. Providing Pacific lamprey passage and infrastructure (#52) would be beneficial, minor, small, short and long term recurring. The effects of the construction of AFFs (#722) and the continued operation of existing adult fish facilities would be negligible, small, in the short and long term recurring.

It should be noted that for each these measures, water treatment at the drinking water facility would mitigate some of the effects of low-quality water. Without treatment, water quality effects would be a higher magnitude, duration or extent.

*3.17.5.9.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) basin-wide; Operation, maintenance, repair, replacement and rehabilitation*

Maintenance and alteration of revetments is a measure common to all alternatives and would occur basin-wide. The effects would be adverse negligible, small, and short term. In the long term, the revetments would have no effects on HABs formation and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects.

Construction effects of these measures would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

*3.17.5.9.2 Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) at Detroit; Green Peter; and Lookout Point dams; Deeper fall reservoir drawdowns for fish passage (#40) at Blue River; Cougar; Detroit; Green Peter; Hills Creek; Lookout Point and Spring reservoir drawdown for downstream fish passage (#720) at Cougar; Detroit; and Lookout Point dams; Fall Creek drawdown*

Using ROs to discharge cold water (#166), deeper fall reservoir drawdowns for fish passage (#40), spring reservoir drawdown for downstream fish passage (#720), and the Fall Creek drawdown would have adverse effects on downstream waters where HABs formation could occur. The effects would be adverse minor, large, short and long term recurring during reservoir releases.

Construction effects of associated with the deeper fall reservoir drawdowns for fish passage (#40) would be adverse negligible, small in the medium term as measures to prevent erosion and sedimentation would be implemented during construction.

###### *3.17.5.9.3 Use spillway for surface spill in summer (#721) at Blue River; Detroit; Foster; Green Peter; Hills Creek; and Lookout Point dams; Pass water over spillway in spring for fish passage (#714) at Big Cliff, Detroit, Dexter, Lookout Point dams*

Using the spillway for surface spill in summer (#721) and spring spillway fish passage (#714) would have beneficial effects on HABs formation. The effects would be beneficial, minor, large, short and long term recurring during summer spillway releases.

###### *3.17.5.9.4 Augment instream flows by using the inactive pool (#718) at Blue River, Cottage Grove; Dorena; and Falls Creek dams; Augment instream flows by using the power pool (#304) at Detroit, Green Peter, Hills Creek, and Lookout Point dams*

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse effects on HABs and public health and safety as water from the deeper portions of the pool would be released. The effects would be minor, large, short and long term recurring during reservoir releases.

###### *3.17.5.9.5 Integrated temperature and habitat flow regime (#30a) basin-wide*

Integrated temperature and habitat flow regime (#30a) would have beneficial effects on reducing HABs formation and public health and safety. The effects would be beneficial, minor, small affecting the downstream waters only, in the short and long term recurring annually.

###### *3.17.5.9.6 Construct adult fish facilities (#722) at Blue River; Green Peter; and Hills Creek dams; Pacific lamprey passage and infrastructure (#52) at Blue River; Green Peter; and Hills Creek dams; Continued operation of existing adult fish facilities*

Providing Pacific lamprey passage and infrastructure (#52) would reduce stagnancy of waters near the location of the fish passage structures due to continual flow of water, thus preventing HAB growth locally. The effects would be beneficial, minor, small, short and long term recurring. The construction of AFFs (#722) and the continued operation of existing adult fish facilities would be negligible, small, in the short and long term recurring.

Construction effects of these measures would be adverse negligible, small, in the short or medium term as measures to prevent erosion and sedimentation would be implemented during construction.

###### *3.17.5.9.7 Near-term Operations Measures*

The effects of the Near-term Operations Measures are analyzed under Section 3.17.2.3.2. They are a suite of operations measures in which the impacts were analyzed by grouping measures which utilize the ROs or releasing water via the spillway. For both approaches the impacts would result in either adverse and/or beneficial, minor, large, short and long-term recurring effects.

###### *3.17.5.9.8 Climate Change*

Alternative 3B would improve fish passage by using operations-focused measures (using a deep drawdown to Cougars Dam's DT). The measures in Alternative 3B would improve water quality by normalizing temperatures and provide fish passage with numerous deep drawdowns. Alternatives 3A and 3B would include more than twice as many drawdowns as the other alternatives, and Alternative 3B would include the deeper drawdown to the Cougar DT. Climate change in combination with the measures under Alternative 3B would have adverse, moderate, large intermittent and/or permanent effects to drinking water in the long term.

##### *3.17.5.10 Alternative 4 – Structures-Based Fish Passage Alternative*

Under Alternative 4, a structures-based approach is proposed to improve fish passage. Near-Term Operations Measure(s) are also proposed under this alternative. The effects of the measures proposed under Alternative 4 are analyzed in this section. Effects are the similar to the effects described under the Discussion of Effects by Measure(s).

Overall, Alternative 4 effects would be similar to Alternatives 1, 2A, 2B, 3A, and 3B. Alternative 4 effects would be adverse negligible, small, in the short term or medium term for the construction and/or modification of any structural measures which include maintenance or alteration of revetments (#9); Foster Fish Ladder Temperature Improvement (#479); construct WTC towers (#105); structural improvements to reduce TDG (#174), restoring upstream and downstream passage at drop structures (#639); construction of AFFs (#722); providing Pacific lamprey passage and infrastructure (#52); and construct structural downstream fish passage (#392).

In the long term, the maintenance or alteration of revetments (#9) would have no effects on HABs formation and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects. Foster fish ladder temperature improvement (#479); the construction of WTC towers (#105); and structural improvements to reduce TDG (#174) would have beneficial and or adverse, minor, large, short and long-term recurring effects.

Using ROs to discharge cold water (#166) and the Fall Creek drawdown would have adverse minor, large, short- and long-term recurring effects. Using the spillway for surface spill in summer (#721) would have beneficial, minor, large, short- and long-term recurring effects. Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse minor, large, short- and long-term recurring effects. Integrated temperature and habitat flow regime (#30a) would have beneficial minor, small effects in the short and long term recurring annually.

Restoring upstream and downstream passage at drop structure (#639), the construction of fish passage infrastructure (#392) and provide Pacific lamprey passage and infrastructure (#52) would be beneficial, minor, small, short and long term recurring. The construction of AFFs (#722) and the continued operation of existing adult fish facilities would be negligible, small, in the short and long term recurring.

It should be noted that for each these measures, water treatment at the drinking water facility would mitigate some of the effects of low-quality water. Without treatment, water quality effects would be a higher magnitude, duration or extent.

##### *3.17.5.10.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) basin-wide; Operation, maintenance, repair, replacement and rehabilitation*

Maintenance and alteration of revetments is a measure common to all alternatives and would occur basin-wide. The effects would be adverse negligible, small, and short term. In the long term, the revetments would have no effects on HABs formation and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects.

Construction effects of these measures would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.17.5.10.2 Foster Fish Ladder Temperature Improvement (#479); Construct WTC towers (#105) at Detroit; Hills Creek; and Lookout Point dams; Structural improvements to reduce TDG (#174) at Cougar; Detroit; Dexter; Foster; Green Peter; and Lookout Point dams*

Foster fish ladder temperature improvement (#479) would have beneficial effects. A new Forebay Warm Water Supply would allow warmer surface from the Foster forebay to be released downstream, resulting in blending with cooler surface water. The effects would be beneficial, minor, large, short and long term recurring during reservoir releases.

The construction of WTC towers (#105) would have beneficial and adverse minor, large, short and long term recurring when reservoir releases occur.

Structural improvements to reduce total dissolved gas (#174) would have beneficial minor, large effects. The effects would be short and long term and permanent in duration.

Construction effects of these measures would be adverse negligible, small in the medium term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.17.5.10.3 Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) at Green Peter Dam; Fall Creek drawdown*

Using ROs to discharge cold water (#166), and the Fall Creek drawdown would have adverse effects on downstream waters where HABs formation could occur. The effects would be adverse minor, large, short and long term recurring during reservoir releases.

##### *3.17.5.10.4 Use spillway for surface spill in summer (#721) at Green Peter Dam*

Using the spillway for surface spill in summer (#721) and spring spillway fish passage (#714) would have beneficial effects on HABs formation. The effects would be beneficial, minor, large, short and long term recurring during summer spillway releases.

##### *3.17.5.10.5 Augment instream flows by using the inactive pool (#718) at Cottage Grove; Dorena; Falls Creek; and Blue River dams; Augment instream flows by using the power pool (#304) at Cougar; Detroit; Green Peter; Hills Creek; and Lookout Point dams*

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse effects on HABs and public health and safety as water from the deeper portions of the pool would be released. The effects would be minor, large, short and long term recurring during reservoir releases.

##### *3.17.5.10.6 Integrated temperature and habitat flow regime (#30a) basin-wide*

Integrated temperature and habitat flow regime (#30a) would have beneficial effects on reducing HABs formation and public health and safety. The effects would be beneficial, minor, small affecting the downstream waters only, in the short and long term recurring annually.

##### *3.17.5.10.7 Restore upstream and downstream passage at drop structures (#639) at Fern Ridge Dam; construct AFF (#722) at Hills Creek Dam; provide Pacific lamprey passage and infrastructure (#52) at Fern Ridge and Hills Creek dams; construct structural downstream fish passage (#392) at Cougar; Detroit; Foster; Hills Creek; Lookout Point, Big Cliff and Dexter dams; Continued operation of existing adult fish facilities*

Restoring upstream and downstream passage at drop structure (#639), providing Pacific lamprey passage and infrastructure (#52), and the construction of fish passage infrastructure (#392) would reduce stagnancy of waters near the location of the fish passage structures due to continual flow of water, thus preventing HAB growth locally. The effects would be beneficial, minor, small, short and long term recurring. The construction of AFFs (#722) and the continued operation of existing adult fish facilities would be negligible, small, in the short and long term recurring.

Construction effects of these measures would be adverse negligible, small, in the short or medium term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.17.5.10.8 Near-term Operations Measures*

The effects of the Near-term Operations Measures are analyzed under Section 3.17.2.3.2. They are a suite of operations measures in which the impacts were analyzed by grouping measures which utilize the ROs or releasing water via the spillway. For both approaches the impacts would result in either adverse and/or beneficial, minor, large, short and long-term recurring effects.

##### *3.17.5.10.9 Climate Change*

Alternative 4 would improve fish passage with structures-based measures. The measures in Alternative 4 would improve water quality by reducing TDG and normalizing temperatures. Alternative 4 would have fewer drawdowns than under all other action alternatives. Therefore, climate change would exacerbate the effects of Alternative 4 more than Alternative 1, but less than Alternatives 2A, 2B, 3A, 3B, and 5. Climate change in combination with the measures under Alternative 4 would have direct, adverse, moderate, large, long-term intermittent and/or permanent effects to drinking water.

#### ***3.17.5.11 Alternative 5 – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)***

Under Alternative 5 – the Preferred Alternative, fish passage would be improved through a combination of modified operations and structural improvements. Alternative 5 is exactly the same as Alternative 2B except the integrated temperature and habitat flow regime (Measure #30a) is replaced with refined integrated temperature and habitat flow regime (Measure #30b). The Near-Term Operations Measure(s) are also proposed under this alternative. The effects of the measures proposed under Alternative 3A are analyzed in this section. Effects are the similar to the effects described under the Discussion of Effects by Measure(s).

Alternative 5 effects would be adverse negligible, small, in the short term or medium term for the construction and/or modification of any structural measures which include maintenance or alteration of revetments (#9); Foster fish ladder temperature improvement (#479); Construct WTC towers (#105); construction of AFFs (#722); providing Pacific lamprey passage and infrastructure (#52); and construct structural downstream fish passage (#392). In the long term, the maintenance or alteration of revetments (#9) would have no effects on HABs formation and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects. Foster fish ladder temperature improvement (#479) and the construction of WTC towers (#105) would have beneficial and or adverse, minor, large, short and long-term recurring effects.

Using ROs to discharge cold water (#166) and the Fall Creek drawdown would have adverse minor, large, short- and long-term recurring effects. Using the spillway for surface spill in summer (#721) would have beneficial, minor, large, short- and long-term recurring effects. Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse minor, large, short- and long-term recurring effects. Refine integrated temperature and habitat flow regime (#30b) would have beneficial minor, small effects in the short and long term recurring annually.

The construction of fish passage infrastructure (#392) and provide Pacific lamprey passage and infrastructure (#52) would be beneficial, minor, small, short and long term recurring. The construction of AFFs (#722) and the continued operation of existing adult fish facilities would be negligible, small, in the short and long term recurring.

It should be noted that for each these measures, water treatment at the drinking water facility would mitigate some of the effects of low-quality water. Without treatment, water quality effects would be a higher magnitude, duration or extent.

###### *3.17.5.11.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) basin-wide; Operation, maintenance, repair, replacement and rehabilitation*

Maintenance and alteration of revetments is a measure common to all alternatives and would occur basin-wide. The effects would be adverse negligible, small, and short term. In the long term, the revetments would have no effects on HABs formation and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects.

Construction effects of these measures would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

###### *3.17.5.11.2 Foster Fish Ladder Temperature Improvement (#479); Construct WTC towers (#105) at Detroit Dam*

Foster fish ladder temperature improvement (#479) would have beneficial effects. A new Forebay Warm Water Supply would allow warmer surface from the Foster forebay to be released downstream, resulting in blending with cooler surface water. The effects would be beneficial, minor, large, short and long term recurring during reservoir releases.

The construction of WTC towers (#105) would have beneficial and adverse minor, large, short and long term recurring when reservoir releases occur.

Construction effects of these measures would be adverse negligible, small in the medium term as measures to prevent erosion and sedimentation would be implemented during construction.

###### *3.17.5.11.3 Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) at Green Peter Dam; Fall Creek drawdown*

Using ROs to discharge cold water (#166), and the Fall Creek drawdown would have adverse effects on downstream waters where HABs formation could occur. The effects would be adverse minor, large, short and long term recurring during reservoir releases.

###### *3.17.5.11.4 Use spillway for surface spill in summer (#721) at Green Peter Dam; Pass water over spillway in spring for fish passage (#714) at Green Peter Dam*

Using the spillway for surface spill in summer (#721) and spring spillway fish passage (#714) would have beneficial effects on HABs formation. The effects would be beneficial, minor, large, short and long term recurring during summer spillway releases.

###### *3.17.5.11.5 Augment instream flows by using the inactive pool (#718) at Blue River and Falls Creek dams; Augment instream flows by using the power pool (#304) at Detroit; Green Peter; Hills Creek; and Lookout Point dams*

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse effects on HABs and public health and safety as water from the deeper portions of the pool would be released. The effects would be minor, large, short and long term recurring during reservoir releases.

###### *3.17.5.11.6 Refine integrated temperature and habitat flow regime (#30b) basin-wide*

Refine integrated temperature and habitat flow regime (#30b) would have beneficial effects on reducing HABs formation and public health and safety. The effects would be beneficial, minor, small affecting the downstream waters only, in the short and long term recurring annually. .

###### *3.17.5.11.7 Construct AFF (#722) at Green Peter Dam; provide Pacific lamprey passage and infrastructure (#52) at Green Peter Dam; and construct structural downstream fish passage (#392) at Detroit; Foster; Lookout Point, Big Cliff and Dexter dams; Continued operation of adult fish facilities*

Providing Pacific lamprey passage and infrastructure (#52) and construction of structural downstream fish passage would reduce stagnancy of waters near the location of the fish passage structures due to continual flow of water, thus preventing HAB growth locally. The effects would be beneficial, minor, small, short and long term recurring. The construction of AFFs (#722) and the continued operation of existing adult fish facilities would be negligible, small, in the short and long term recurring.

Construction effects of these measures would be adverse negligible, small, in the short or medium term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.17.5.11.8 Near-term Operations Measures*

The effects of the Near-term Operations Measures are analyzed under Section 3.17.2.5.2. They are a suite of operations measures in which the impacts were analyzed by grouping measures which utilize the ROs or releasing water via the spillway. For both approaches the impacts would result in either adverse and/or beneficial, minor, large, short and long-term recurring effects.

##### *3.17.5.11.9 Climate Change*

Alternative 5 is essentially the same as 2B. The measures in Alternative 5 would improve water quality by reducing TDG and normalizing temperatures. It would also provide fish passage. However, it would not improve reservoir storage like Alternative 1. Due to one more deep drawdown than Alternative 2A, climate change would exacerbate the effects of Alternative 5 more than Alternatives 1 or 2A. But overall, the effects would be the same as under Alternative 2A and 2B; climate change in combination with the measures under Alternative 5 would have direct, adverse, moderate, large, long-term intermittent and/or permanent effects to drinking water.

#### ***3.17.5.12 Summary of Effects***

Alternatives 2A, 2B, 3A, 3B, 4, and 5 promote improving water quality by allowing the continual flow of water from the surface spillways, reduce TDGs and normalize temperatures prevent the formation of HABs thereby reducing effects on public health and safety. Alternative 1 has an emphasis on improving reservoir storage, which can cause sediment, metals and nutrients to accumulate increasing the potential for causing a HABs event within the reservoirs. Alternatives with greater drawdowns or use of the regulating outlets such as Alternatives 2A, 2B, 3A and 3B would also improve water quality within the reservoir itself by reducing sediment buildup and nutrients within the reservoir itself, however the drawdowns would release the sediment downstream where a HABs event could occur. Alternatives 4 and 5 have the least number of drawdowns while also improving water quality and overall would have less severe and more beneficial impacts compared to the other alternatives.

## 3.18 PUBLIC HEALTH AND SAFETY – HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

This section addresses hazardous, toxic and radioactive waste (HTRW) in the WVS and WRB. The term "HTRW" is used generally by USACE to describe hazardous waste, but radioactive waste does not apply to this project because USACE does not manage radioactive waste in the WVS.

### 3.18.1 Affected Environment

Hazardous waste is generated currently and exists in the WVS from historic activities, ongoing and routine operations and maintenance, and initial construction. The area of analysis for HTRW is the WVS, but also includes some nearby facilities on private property within the WRB such as mines, from which contamination has migrated onto USACE property. Rather than being organized by geographic area (sub-basins), this section begins with a regulatory overview, is then organized by activity, and concludes with legacy environmental contamination.

#### *3.18.1.1 Regulatory Overview*

As noted above, the term "HTRW" is used generally by USACE, but radioactive waste does not apply to this project because USACE does not manage radioactive waste in the WVS. This section primarily focuses on hazardous waste, which is defined and regulated by the Resource Conservation and Recovery Act (RCRA) see Chapter 7 for additional information. RCRA defines hazardous waste as a waste that exhibits ignitability, corrosivity, reactivity, or toxicity, or is listed on one of the EPA's lists of wastes from non-specific sources, specific sources, or discarded commercial chemical products. RCRA establishes the framework to manage hazardous waste from the "cradle-to-the-grave" and stipulates requirements for waste generators, amongst other categories such as transporters and treatment, storage, and disposal facilities. Waste generators are generally grouped into three categories that each have different requirements, depending on the quantity of waste produced and/or stored on site: Large Quantity Generators (LQGs), Small Quantity Generators (SQGs), and Conditionally-Exempt Small Quantity Generators (CESQGs) or Very-Small Quantity Generators (VESQGs). Some states play a large role in implementing RCRA regulations: the EPA has authorized some states, such as Oregon, to set more stringent standards than those set by the EPA, and implement their hazardous waste requirements by issuing permits.

Legacy contamination is primarily regulated by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), which is discussed further in Section 3.18.1.6 below.

#### *3.18.1.2 Hazardous Waste Generation and Storage at WVS Dams*

The 13 USACE dams that comprise the WVS are each considered Conditionally Exempt Small Quantity Generators (CESQGs) as defined in Chapter 16 of Oregon's Small Quantity Hazardous Waste Generator Handbook. CESQGs produce up to 220 pounds (100 kg) of hazardous waste or hazardous waste residues (including contaminated soils) per month, or less than 2.2 pounds (1 kg) of acute hazardous waste per month. Some of the hazardous waste generated and stored at

WVS dams includes used oil from turbines and transformers, lead-based paint (LBP) debris from demolition or renovation, and universal waste such as aerosol cans and lamps. Detroit, Fall Creek, and Foster dams have dedicated hazardous waste storage buildings that are fire-rated and include secondary containment for spills. The generation of very small quantities of hazardous waste at the facilities would occur through the life of the WVS.

Management of hazardous waste within the WVS complies with all applicable Federal, State, and local requirements. Requirements include the inventorying and reporting requirements of Title III of CERCLA, also known as the Emergency Planning and Community Right to Know Act (EPCRA), and in accordance with regulations identified in 40 CFR 262, Standards Applicable to Generators of Hazardous Waste, and Oregon Administrative Rules (OAR) 340-100, Hazardous Waste Management. CESQGs may store up to 2,200 pounds (1,000 kg) of waste before the waste must be shipped to a permitted off-site treatment, disposal, or recycle facility.

#### *3.18.1.3 Transport of Hazardous Wastes*

The transport of hazardous wastes on public roadways is controlled by United States Department of Transportation (USDOT) regulations. Any transport of such wastes to or from a project site must be done in compliance with these regulations to protect public health and safety. The hazardous waste transported is that which is generated and stored as described above in Section 3.18.1.2. All hazardous waste would be transported by commercial carriers contracted by the USACE in accordance with the hazardous substances shipping requirements of CFR Title 49 and in compliance with the Federal Motor Carrier Safety Regulations of the DOT, parts 383, 390, 397, and 399.

In the event of a release or spill, the transportation company would be responsible for response and cleanup. USACE would specify that the contract carriers be licensed and inspected as required by the Oregon Department of Environmental Quality (DEQ) and Oregon Department of Transportation (DOT). The permits, licenses, and certificates are the responsibility of the carrier. CFR Title 49 requires that all shipments of hazardous substances be properly identified and placarded. Shipping documents must be accessible and include safety data sheets (SDS) that contain information describing the hazardous substance, immediate health hazards, fire and explosion risks, immediate precautions, firefighting information, procedures for handling leaks or spills, first aid measures, and emergency response telephone numbers. Hazardous wastes would be properly disposed of in accordance with RCRA regulations. Transportation of these wastes would adhere to all applicable State and Federal regulations including requirements for hazardous waste manifests with shipments, labeling or using placards, and emergency information requirements.

#### *3.18.1.4 Legacy Environmental Contamination*

Legacy environmental contamination exists within the WRB from historic mining activities and initial construction of the WVS. Contamination from historical mining primarily involves heavy metals, with mercury generally posing the greatest risk to public health and safety. Contamination from the construction of the WVS includes hazardous or toxic substances such as diesel, polychlorinated biphenyls (PCBs), and heavy metals. Specific sites and sources are detailed below.

#### *3.18.1.5 Mercury and Mine Waste Sites*

Mercury is a heavy metal and neurotoxin that can have severely negative health effects on humans and wildlife, depending on a number of factors. Exposures to inorganic mercury (Hg) are most common when liquid mercury is spilled and the vapors are inhaled. However, mercury in its methylated form ($CH_3Hg$) is more toxic to vertebrates than inorganic mercury (EPA 2021g). Mercury methylation occurs as a result of naturally occurring sulfate-reducing bacteria reacting with inorganic mercury. Methylmercury is fat soluble, allowing it to easily bioaccumulate in organisms like fish. Because of this, Oregon has a statewide consumption advisory on bass sportfish, as well as more detailed advisories based on the consumer's age, water body, and type of fish (OHA No Date-b).

Although mercury is an element that occurs naturally in geologic formations within the earth, as long as it is sequestered there its presence does not typically cause problems unless extracted by humans. One significant global source of mercury is mining (AMAP/UN Environment 2019). Oregon has a rich history of mining (DOGAMI No Date), including the mining of cinnabar (mercury ore, Hg-S). Legacy contamination exists from historic mining activities, including within the WVS (Jackson, Eagles-Smith, and Emery 2019), where hydrologic events have moved contamination onto USACE property (EPA 2018).

##### *3.18.1.5.1 Black Butte Mine*

The Black Butte Mine was a cinnabar mine within the Coast Fork Willamette River watershed, located 7.5 miles upstream of Cottage Grove Reservoir to the north. Mine waste materials, such as tailings and waste rock, contain mercury and other toxic metals. Mercury has been released into Cottage Grove Reservoir and the Coast Fork Willamette River from hydrologic events eroding and transporting mine materials (EPA 2018). Here, mercury primarily exists as inorganic mercury in rock and sediment and methylmercury in fish tissue. Due to the public health risk, the Black Butte Mine was added to the EPA's Superfund National Priorities List (NPL) in 2010, making it eligible for federal funding to provide long-term cleanup under the Comprehensive Environmental Response and Liability Act (CERCLA). In 2018, two removal actions occurred, where Furnace Creek, the primary source of mercury-contaminated soil was excavated. These actions focused on reducing material that is easily mobilized downstream or has a substantial contact risk to people. After 13,100 cubic yards of contaminated soils were removed and stored in an onsite repository, Furnace Creek's stream channel and banks were restored, stabilized, and the area was seeded with native plants. Post-construction monitoring still occurs at the site (EPA 2018).

Although two removal actions have occurred at the Black Butte Mine site, mercury-containing sediment still exists in the area. CDM Smith, the EPA's prime contractor for the Black Butte Mine removal actions, determined in a post-removal risk assessment that the total cancer risks associated with residential exposure were within the EPA's acceptable risk range but above the

ODEQ range, despite a lack of data relating mercury exposure to cancer (CDM Smith 2020; EPA 2005). The noncancer hazard for a child was still above the threshold, primarily due to exposure to mercury-contaminated sediment (CDM Smith 2020). However, it should be noted that the Black Butte Mine is still an active CERCLA site: its listing remains on the NPL and it is currently in the remedial investigation/feasibility study phase (see section 3.18.1.6 below for more information on the CERCLA process).

##### *3.18.1.5.2 Bohemia Mining District*

The Bohemia Mining District is a 9-square mile area located approximately 18 miles upstream of Dorena Reservoir to the southeast. This mining district contained multiple mines that used inorganic mercury for over 60 years to recover gold and silver as part of an amalgamation process (Hygelund, Ambers, and Ambers 2001). Limited inspections for hazardous waste and materials have occurred within the Bohemia Mining District because only part of the property is owned by the U.S. Forest Service (USFS) and the rest of the property is privately owned. While some contamination certainly exists due to the history of the area, the contamination has not warranted listing as a brownfield site or on the EPA's Superfund National Priorities List (ODEQ 2021c).

It was believed that fish in Dorena Reservoir were contaminated with mercury, but the source was unconfirmed until a 2001 study by Hygelund et al. That study analyzed the mercury content of fine-grained sediment samples from streams that do not drain the Bohemia Mining District, streams that do drain the Bohemia Mining District, mine waste piles, and Dorena Reservoir sediment (Table 3.18-1). The study strongly suggested that the source of the mercury contamination in the Dorena Reservoir Watershed is the Bohemia Mining District, but was not able to rule out the naturally high mercury content of soils and rock in the area as a source (Hygelund, Ambers, and Ambers 2001). Although Dorena Reservoir has a much lower concentration of mercury in its sediment than Cottage Grove Reservoir, a fish consumption advisory is still in effect for both reservoirs.

**Table 3.18-3.18-1. Mercury Concentrations in the Dorena Reservoir Watershed**

| Sample Area | Mercury Concentration (ppm)[1] |
|---|---|
| Sediment in streams not draining the mining district | 0.006 |
| Sediment in streams draining the mining district | 0.14 - 1.339 |
| Dorena Reservoir sediment | .025 - .095 |
| Mine Waste Rock[2] | 10 - 50 |

[1]Data from Hygelund, Ambers, and Ambers 2001., 2001; ppm = parts per million

[2]That which is removed from a mine as part of the mining process, but has no economic value.

#### ***3.18.1.6 CERCLA Sites***

The CERCLA, also known as Superfund, provides a federal fund to clean up uncontrolled or abandoned hazardous waste sites as well as accidents, spills, and other emergency releases of pollutants and contaminants into the environment. The CERCLA process has nine steps, described below.

1. Preliminary Assessment/Site Inspection: Review historic information and visit site to evaluate the potential for hazardous substance releases.
2. National Priority Listing (NPL): Rank hazards using the EPA's Hazard Ranking System, which quantifies risks and prioritizes which sites warrant further investigation. Only the most hazardous sites are listed on the NPL.
3. Remedial Investigation/Feasibility Study: Characterize the nature and extent of contamination, as well as assess threats to human health and the environment. Evaluate performance and cost of various contaminant treatment options.
4. Records of Decision: Explain which cleanup alternative will be used.
5. Remedial Design/Remedial Action: Develop and implement detailed cleanup plans.
6. Construction Completion: Complete all necessary construction outlined during the Remedial Design step.
7. Post Construction Completion: Continue to monitor site.
8. National Priorities List Deletion: Delete site from NPL once cleanup goals have been achieved.
9. Site Reuse/Redevelopment: Reuse or redevelop site in a safe manner agreeable with local plans.

The only site within the WVS that has been placed on the NPL is the Black Butte Mine, which is described above in Section 3.18.1.5.1, because its contamination source fundamentally differs from the majority of other WVS CERCLA sites. Most of the contamination at WVS CERCLA sites came from industrial waste disposal that occurred during the initial construction of the dams. Contaminants include petroleum, solvents, metals, and PCBs, amongst others, and sites are in various stages of the CERCLA process (Table 3.18-2).

**Table 3.18-3.18-2. USACE WVS CERCLA Site Summaries**

| WVS Project | Contamination Source | Contaminants | CERCLA Progress | Summary |
|---|---|---|---|---|
| Big Cliff | Project waste disposal | Petroleum, heavy metals, volatile organic compounds (VOCs; submerged[2]) | Feasibility study nearly complete | Contaminants present in sediment from improper waste disposal during the initial construction of the dam. Surface water sampling suggests no risks to downstream communities. |

| WVS Project | Contamination Source | Contaminants | CERCLA Progress | Summary |
|---|---|---|---|---|
| Blue River | Project waste disposal | Heavy metals, pesticide (submerged[2]). | Site Investigation complete. Remedial Investigation funding requested | Contaminants present in sediment near the saddle dam, although not necessarily in levels high enough to warrant a cleanup. Further investigation is recommended. |
| Cottage Grove[1] | Mercury mine | Mercury, arsenic | One time-critical and one non-time-critical removal action complete. Long-term monitoring is in progress, but ongoing investigations are occurring that may result in further removal action(s). | Contaminants present in Cottage Grove sediment from the upstream Black Butte cinnabar mine. 13,100 cubic yards of contaminated soil were removed from the mine during a removal action in 2018, but the site is still in the remedial investigation/feasibility study phase. |
| Cougar | Unclear, but likely from fuel leaks and spills during initial construction | Petroleum | Site investigation partially complete. Funding requested | Petroleum contaminated soils were discovered during O&M activities. 7,000 cubic yards of soil removed. No further action is needed as contaminants are not detected above residential preliminary remediation goals. |
| Detroit | Project waste disposal | Petroleum, heavy metals, PCBs | Site investigation complete. Remedial Investigation funding requested | Multiple contamination sites in the area. Cleanup documentation is unclear, but at least three separate contaminated soil removal actions took place in the 90s. Further investigation is recommended. |
| Dexter | Domestic and project waste disposal | PCBs, mercury | Site investigation partially complete. Funding requested | Solid waste scattered around roadside dump near powerhouse. No remediation actions have occurred but further investigation is recommended. |

| WVS Project | Contamination Source | Contaminants | CERCLA Progress | Summary |
|---|---|---|---|---|
| Dorena | Project waste disposal | VOCs, heavy metals | Site Investigation complete | Contaminants present but near background levels consistent with that reported in the area. Sampling suggests there is no significant threat to humans or the environment. |
| Fall Creek | Project O&M chemical storage | Lead, arsenic | Site Investigation complete | Contaminants present from former chemical storage area. Several cleanup operations occurred, but documentation is unclear. No further steps will be taken to list this site on the NPL. |
| Green Peter | Project waste disposal | Petroleum, solvents, heavy metals | Site Investigation complete. Remedial investigation funding requested | Contaminants present from disposal of various toxic and hazardous liquid wastes. Some level of cleanup has occurred for petroleum-contaminated soils, but documentation is unclear. A limited site inspection is recommended. |

[1]The Cottage Grove Reservoir contamination is a product of historic mining activities and not related to USACE. Cottage Grove is the only CERCLA site in this table that is not from USACE-related activities.

[2]Contaminants are generally submerged below the surface of the reservoir. Contaminants are located at historic landfills and contractor work areas that were used during the initial construction of the dams but are now covered with water for most of the year.

Sources: (EPA 2011; USACE 2013c; USACE 2014d; USACE 2014e; USACE 2015j; USACE 2015k; USACE 2021c; USACE No date-n)

### 3.18.2 Environmental Effects

This section discusses the potential effects of the Proposed Action and alternatives on public health and safety from hazardous, toxic, and radioactive waste (HTRW). The discussion includes the methodology used to assess effects, the measures within the action alternatives that were analyzed, a summary of the effects, and a detailed analysis of effects under each alternative.

#### *3.18.2.1 Methodology*

The potential effects to public health and safety from HTRW were assessed by examining ongoing trends in legacy contamination and the generation, storage, and presence of hazardous waste in soil, sediment, air, and water (exposure pathways) with regards to public health and safety within the WVS. These trends were analyzed with respect to how they could be affected by the action alternatives using information from USACE, scientific literature, and reports. This information was then used to qualitatively predict the severity of the threat that HTRW poses to public health and safety over the life of the project. Table 3.18-3 describes the evaluation criteria for the magnitude, duration, and extent, and provides a definition for the scale of each effect factor.

**All comparisons of effects for each action alternative are in comparison to the NAA unless stated otherwise.**

**Table 3.18-3.18-3. Evaluation Criteria for Potential Effects to Public Health and Safety from Hazardous, Toxic, and Radioactive Waste**

| Term | Definition |
|---|---|
| **Magnitude** | |
| Negligible | The risk to public health from HTRW would be nondetectable or very small. |
| Minor | The risk to public health from HTRW would be measurable but below regulatory standards. |
| Moderate | The risk to public health from HTRW would be measurable and near (slightly above or below) regulatory standards. Mitigation measures would be necessary and would reduce the risk of adverse public health effects. |
| Major | The risk to public health from HTRW would be readily measurable and substantially above regulatory standards. Mitigation measures would be required to decrease the risk of adverse public health effects. |
| **Duration** | |
| Short term | Alteration lasts for the duration of small construction projects, and is continuous for less than 2 years. |
| Medium term | Alteration is limited to the duration of large construction projects, and is continuous for a period of 2-5 years. |
| Long term | Alteration is permanent or lasts continuously beyond operation changes or the completion of all construction projects; the alteration recurs at regular intervals (i.e., deep drawdowns that occur for a 3-week period in the fall and/or spring); or the alteration occurs intermittently. |
| **Extent** | |
| Small | Effects would be confined to the project area. |
| Medium | Effects would be perceived throughout a single county, multiple counties, or the entire WVS. |
| Large | Effects would be perceived throughout the entire state. |

#### *3.18.2.2 Measures Analyzed for Public Health and Safety- Hazardous, Toxic, and Radioactive Waste*

The measures that could affect public health and safety from HTRW are: operation, maintenance, repair, replacement, and rehabilitation; Foster fish ladder temperature improvement (#479); provide Pacific lamprey passage and infrastructure (#52); construct water temperature control tower (#105); construct structural downstream fish passage (#392);

structural improvements to reduce total dissolved gas (#174); deeper fall reservoir drawdowns for fish passage (#40); use spillway for surface spill in summer (#721); and construct adult fish facility (#722). The following measures would have no effect on public health and safety from HTRW, and are therefore not discussed further.

- Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166);
- Integrated temperature and habitat flow regime (#30a);
- Augment instream flows by using the power pool (#304);
- Gravel augmentation below dams (#384);
- Restore upstream and downstream passage at drop structures (#639);
- Pass water over spillway in spring for fish passage (#714);
- Augment instream flows by using the inactive pool (#718);
- Adapt Hatchery Program (#719);
- Spring reservoir drawdown for downstream fish passage (#720);
- Reduce minimum flows to Congressionally authorized minimum flow requirements (#723);
- Maintenance of existing and new fish release sites above dams (#726); and
- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9).

A summary of the effects to public health and safety from hazardous, toxic, and radioactive waste is provided in Table 3.18-4.

Note that where a range of potential effects would occur, the most severe magnitude of adverse effects and the lesser magnitude of beneficial effects for each alternative was listed in this table. For example, if there is a range of minor to moderate adverse effects, moderate adverse effects are included in the table. If beneficial effects would range from minor to moderate, the table includes minor beneficial effects. Said otherwise, the most conservative conclusions of potential effects are presented in the table below in order to avoid overstating potential beneficial effects and understating adverse effects. Also, the extent of effects includes all reservoirs where potential effects would occur, even if the most severe adverse effect or the lesser beneficial effect does not occur at that reservoir. This follows the approach to present the most conservative conclusions in this table; instead of simply omitting reservoirs where less severe or more beneficial effects would occur. Discussions of all adverse and beneficial effects are included below.

**Table 3.18-4. Summary of Effects to Public Health and Safety from Hazardous, Toxic, and Radioactive Waste**

| Effect Factor | Alternative | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **NAA** | **1** | **2a** | **2b** | **3a** | **3b** | **4** | **5** |
| | **Short-Term** | | | | | | | |
| Magnitude | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse |
| Extent | Local (basin-wide) | Local (basin-wide, FRN, GPR) | Local (basin-wide, GPR) | Local (basin-wide, GPR) | Local (basin-wide, BLU, HCR, GPR) | Local (basin-wide, BLU, HCR, GPR) | Local (basin-wide, FRN, HCR) | Local (basin-wide, GPR) |
| | **Medium-Term** | | | | | | | |
| Magnitude | Minor adverse | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse |
| Extent | Local (basin-wide) | Local (DET, CGR, DEX, FOS, GPR, LOP) | Local (CGR, DET, FOS, GPR, LOP) | Local (CGR, DET, FOS, GPR, LOP) | Local (BLU, GPR, HCR) | Local (BLU, CGR, GPR, HCR) | Local (DET, HCR, LOP, FOS, CGR, DEX, GPR) | Local (CGR, DET, FOS, GPR, LOP) |
| | **Long-Term (Permanent, Intermittent, or Recurring)** | | | | | | | |
| Magnitude | Minor to moderate adverse | Minor to moderate adverse | Minor to moderate adverse | Minor to moderate adverse | Minor to moderate adverse | Minor to moderate adverse | Minor to moderate adverse | Minor to moderate adverse |
| Extent | Statewide | Statewide, local (basin-wide) | Statewide, local (basin-wide) | Statewide, local (basin-wide) | Statewide, local (basin-wide) | Statewide, local (basin-wide) | Statewide, local (basin-wide) | Statewide, local (basin-wide) |
| Duration Type | Permanent | Permanent | Permanent | Permanent | Permanent and Recurring | Permanent and Recurring | Permanent | Permanent |

### *3.18.2.3 Discussion of Effects by Measure*

This section applies the methodology described above to each measure analyzed for HTRW to determine the potential effects. The discussion is grouped by measures that would have similar effects where possible. Operation, maintenance, repair, replacement, and rehabilitation, use spillway for surface spill in summer (#721); provide Pacific lamprey passage and infrastructure (#52); Foster fish ladder temperature improvement (#479); structural improvements to reduce total dissolved gas (#174); construct adult fish facility (#722); construct water temperature control tower (#105); construct structural downstream fish passage (#392); and deeper fall reservoir drawdowns for fish passage (#40) would require construction as described above in Section 3.1.4.2. Site-specific project details for each construction measure will be determined during the preconstruction engineering and design phase. While general, qualitative effects from construction are discussed below on a programmatic level, the more detailed, site-specific analysis will be included in the tiered EA or EIS.

#### *3.18.2.3.1 Operation, Maintenance, Repair, Replacement and Rehabilitation*

The effects of operation, maintenance, repair, replacement, and rehabilitation would be negligible in magnitude, local in extent, adverse, and short- and long-term for routine/scheduled maintenance; and be negligible to minor in magnitude depending on the activity, local in extent, adverse, and medium- and long-term in duration for major maintenance and rehabilitation.

Routine maintenance would result in small amounts of hazardous waste being generated by the scheduled maintenance of turbines and transformers, lead-based paint (LBP) debris from demolition or renovation, and universal waste such as aerosol cans and lamps. The amount of waste generated would be less than the CESQG limit of 220 pounds (100 kg) per month. USACE would comply with RCRA regulations and follow BMPs, including but not limited to: providing workers with safety training and PPE[57], installing secondary containment for waste where applicable, and maintaining accurate waste documentation. Therefore, effects would be adverse and negligible in magnitude. Major maintenance and rehabilitation could result in small amounts of hazardous waste being generated by activities that would still be under the CESQG limit, similar to routine maintenance or, for example, the modernization of the Detroit Dam ROs.

Major maintenance and rehabilitation also result in the generation of hazardous waste that would exceed the CESQG limit during unique circumstances could. There has only been one CESQG exceedance: a 2007 electrical fire in the Detroit Dam Powerhouse that required approximately 20 cubic yards of hazardous waste to be shipped off site of during rehabilitation activities. However, this event was an anomaly and the waste generator status of dams as CESQGs would remain for the life of the project. USACE would continue to adhere to applicable BMPs and regulations, including but not limited to wearing PPE, coordinating with ODEQ and

[57] The USACE Willamette Valley Project Hazard Communication Plan is summarized below in Section 3.19.1.1, Hazardous Materials.

EPA, and restricting access when appropriate. Therefore, effects would be negligible to minor in magnitude for large construction projects. Effects for both routine and major maintenance would be local in extent because they would be confined to the project area. While routine maintenance projects would be short-term because they would take less than two years and major maintenance projects would be medium-term because they would take more than two years, the effects of both routine and major maintenance would occur for the life of the project, and therefore, also be long-term in duration.

Therefore, potential adverse effects would be negligible in magnitude, local in extent, adverse, and short- and long-term for routine/scheduled maintenance; and be negligible to minor in magnitude depending on the activity, local in extent, adverse, and medium- and long-term in duration for major maintenance and rehabilitation.

##### *3.18.2.3.2 Use spillway for surface spill in summer (#721) and Provide Pacific lamprey passage and infrastructure (#52)*

The effects of using the spillway for surface spill in the summer and providing Pacific lamprey passage and infrastructure would be negligible in magnitude, local in extent, adverse, and short-term in duration.

These measures would only have effects on public health and safety from HTRW during construction activities. Using the spillway for surface spill in the summer would require structural modifications with excavators and concrete in order to make the spillway useable. Providing Pacific lamprey passage and infrastructure may require modifying fish passage infrastructure with metal strips to provide areas for lamprey to attach. These measures would involve construction and could require compressed gasses for cutting, welding, and brazing, or could otherwise require hazardous material and generate hazardous waste from construction activities in general. Common components of hazardous waste streams from construction sites include lead, asbestos, paint thinners and strippers, aerosol cans, and fluorescent bulbs (Stanford Environmental Health and Safety No date). These measures would likely not require these types of materials or generate these types of wastes because they primarily involve work with construction equipment, metal, and concrete, rather than the construction or demolition of buildings.

Compressed gas cylinders could be classified as hazardous waste if they originally contained a hazardous material and have been spent (i.e., no longer serves the purpose for which it was produced). However, spent compressed gas cylinders would likely be returned to the vendor, and the EPA has determined that compressed gas cylinders that are returned by customers for re-use, refilling, and re-issue are not considered wastes (EPA 1980). If the compressed gas cylinders were to be discarded, or other forms of hazardous wastes were generated during construction, the wastes would be treated as hazardous and stored in accordance with the projects’ CESQG status until being shipped off site for disposal. Consequently, these measures could result in the generation of small amounts of hazardous waste, but the effects would be adverse and negligible in magnitude. Because the waste would be contained in cylinders, drums, or other vessels pursuant to RCRA regulations, the effects to public health and safety would be confined to the project area, and thus, be local in extent. Small amounts of waste would be generated during the construction activities that would take less than two years to complete, so the effects would be short-term in duration.

Therefore, potential adverse effects would be negligible in magnitude, local in extent, adverse, and short-term in duration.

##### *3.18.2.3.3 Foster Fish Ladder Temperature Improvement (#479) and Structural improvements to reduce total dissolved gas (#174)*

The effects of improving the Foster fish ladder and improving structures to reduce TDG would be negligible in magnitude, local in extent, adverse, and medium-term in duration.

Improving the Foster fish ladder would involve boring a hole through the Foster Dam, attaching a prefabricated intake structure to the hole using barge-mounted cranes, and then installing mechanical and electrical systems. Improving structures to reduce TDG could involve installing rebar dowels into bedrock and placing concrete. TDG structures would be integrated within the WTC towers at Detroit, Green Peter, and Lookout Point, and therefore, there would be no separate structures built to reduce TDG at these locations. Similar to the measures described above in Section 3.18.2.3.2, these measures could potentially generate small amounts of hazardous waste from activities such as using compressed gasses for cutting, welding, and brazing, or could otherwise require hazardous material and generate small amounts of hazardous waste from construction activities in general.

Therefore, potential adverse effects would be negligible in magnitude, local in extent, adverse, and medium-term in duration.

##### *3.18.2.3.4 Construct water temperature control tower (#105), Construct structural downstream fish passage (#392), and Construct adult fish facility (#722)*

The effects of constructing WTC towers, structural downstream fish passage, and AFFs would be negligible in magnitude, local in extent, and adverse in both the medium and long term.

The specific design and techniques for constructing WTC towers are not available at the programmatic level. Constructing structural downstream passage would involve either FSCs or FSSs depending on the dam, and at Foster Dam, the fish weir would be modified. FSC and FSS construction would involve off-site metal fabrication of the passage structure itself, and then affixing the structure to the WTC tower. Modifying the Foster Dam fish weir would require structural, mechanical, and electrical work to be completed on the spillway gate. Constructing AFFs would involve earthwork, concrete placement, in-water-work, mechanical, and electrical work to construct trap and haul facilities similar to those built at Cougar, Minto, Foster, and Fall Creek. Like the measures described above in both Sections 3.18.2.3.2 and 3.18.2.3.3, these measures could potentially generate small amounts of hazardous waste from activities such as using compressed gasses for cutting, welding, and brazing, or could otherwise require hazardous material and generate small amounts of hazardous waste from construction activities in general. FSC and FSS construction would take more than two years, so the effects would be medium-term in duration. Modifying the Foster Dam fish weir would take less than two years, so effects would be short-term in duration.

After construction, these measures would continue to have effects from operation. WTC towers effectively serve as hydropower turbine intakes and would require hydraulic-oil-filled systems to adjust the gates that control water flows. Additionally, WTC towers, fish passage structures, and AFFs would each require the installation of an emergency diesel generator (EDG) to power equipment during power interruptions. Oil has a finite life, and due to routine equipment maintenance (i.e., oil changes), these oil-filled systems would produce small amounts of hazardous waste. However, the wastes would be treated as hazardous (as applicable) and stored in accordance with the projects' CESQG status until being shipped off site for disposal, and therefore, effects would be adverse and negligible in magnitude. Because the waste would be contained in cylinders, drums, or other vessels pursuant to RCRA regulations, the effects to public health and safety would be confined to the project area, and thus, be local in extent. The small amounts of waste generated would continue for the life of the project and would not change the waste-generator status of the projects as CESQGs, so the effects would be long-term in duration.

Therefore, the potential adverse effects would be negligible in magnitude, local in extent, and adverse in both the medium and long term.

###### *3.18.2.3.5 Deeper fall reservoir drawdowns for fish passage (#40)*

The effects of deeper fall reservoir drawdowns for downstream fish passage would be negligible in magnitude, local in extent, and adverse in the medium and long term, and be minor in magnitude, local in extent, and adverse, and recurring in the long term.

At Cougar Dam, an intake and access tower would be constructed to use the diversion tunnel as a routine outlet for deep drawdowns. At Detroit, Green Peter, and Lookout Point, EDGs would be installed to control water gates during a power interruption, as the current cooling water intakes are located too high to be used during deep drawdowns. And at the Blue River Reservoir, deep drawdowns could expose previously inundated legacy-contaminated sediment near the saddle dam.

Like the measures described above in Section 3.18.2.3.2 constructing an intake and access tower at Cougar Dam required for the drawdown to the DT could potentially generate small amounts of hazardous waste from activities such as using compressed gasses for cutting, welding, and brazing, or could otherwise generate small amounts of hazardous waste from construction activities in general and during O&M of oil-filled systems. Additionally, the installation of EDGs at Detroit, Green Peter, and Lookout Point would generate small amounts of hazardous waste during O&M of oil-filled systems. Constructing an intake and access tower at Cougar Dam would take more than two years, so the effects would be medium-term in duration. The generation of small amounts of hazardous waste during O&M of oil-filled systems would continue for the life of the project, so effects would be long term. The wastes would be treated as hazardous (as applicable) and stored in accordance with the projects' CESQG status until being shipped off site for disposal, and therefore, effects would be adverse and negligible in magnitude. Because the waste would be contained in cylinders, drums, or other vessels pursuant to RCRA regulations, the effects to public health and safety would be confined to the project area, and thus, be local in extent.

At the Blue River Dam, deeper fall reservoir drawdowns could expose the previously inundated legacy-contaminated sediment near the saddle dam, described above in Section 3.18.1.6. This would increase the risk to public health and safety because the contamination would potentially become accessible to the public (the water that would typically make the contamination inaccessible would be drawn-down). If contaminated sediment were to dry, contaminants could also spread due to wind erosion and deposition. A previous site investigation indicated that contaminants may not exist in levels high enough to warrant a cleanup, but concluded by recommending further investigation. While the deeper drawdown would increase the risk to public health and safety, the risk could be reduced by using administrative controls, such as signage, security patrols, and fencing to restrict access to the reservoir while it is drawn-down if needed. Further, the spreading of contamination from wind erosion could be mitigated by using temporary windbreaks or wetting the area, if determined necessary. However, as stated in the Air Quality resource under Section 3.10.3.3.3, average wind speeds would not be high enough to entrain the (contaminated) sediment into the air. Therefore, the effects would be adverse and minor in magnitude. The drawdowns would occur for approximately three weeks out of the year and recur annually for the life of the project, so effects would be short term and long-term recurring. Effects to public health and safety would be confined to the project, so they would be local in extent.

Therefore, the effects of deeper fall reservoir drawdowns for downstream fish passage would be negligible in magnitude, local in extent, and adverse in the medium and long term, and be minor in magnitude, local in extent, and adverse, recurring in the long term.

#### *3.18.2.3.6 Suite of Near-term Operations*

The majority of the near-term operations involve water-management operations, and thus, would not have effects on public health and safety from HTRW. The deep drawdowns for improved downstream fish passage at Green Peter and Lookout Point dams would require the installation of an EDG and would generate small amounts of hazardous waste during its O&M for the life of the project, so effects would be long term. The waste would be treated as hazardous (as applicable) and stored in accordance with the projects' CESQG status until being shipped off site for disposal, and therefore, effects would be adverse and negligible in magnitude. Because the waste would be contained in cylinders, drums, or other vessels pursuant to RCRA regulations, the effects to public health and safety would be confined to the project area, and thus, be local in extent. Therefore, the effects of the suite of near-term operations would be negligible in magnitude, local in extent, and adverse in the long term.

### *3.18.2.4 No Action Alternative*

Under the NAA, the existing O&M of the WVS would continue. The O&M of this system includes the generation, storage, and transportation of hazardous waste and the presence of legacy contamination. The NAA assumes that ongoing activities would continue.

Hazardous waste would continue to be generated, stored, and transported throughout the basin from the operation, maintenance, repair, replacement, and rehabilitation of the WVS, from, including but not limited to, the lubrication of hydropower turbines and insulation of electrical transformers, as well as smaller sources such as maintenance, construction, and demolition. USACE WVS dams have historically produced hazardous waste far under their allowed CESQG limit of 220 pounds per month. There has only been one CESQG exceedance: the 2007 Detroit Dam powerhouse fire described above in Section 3.18.2.3.1, which was an anomaly. The waste generator status of dams as CESQGs would remain for the life of the project and USACE would continue complying with RCRA regulations and following BMPs as described above in Section 3.18.2.3.1. Therefore, the effects from ongoing operation, maintenance, repair, replacement, and rehabilitation under the NAA would be identical to those described above: negligible to minor in magnitude, adverse, local in extent, in the short- medium- and long-term.

The presence or management of WVS legacy contamination would not change under the NAA. The legacy contamination is associated with two major sources: waste from mining, and waste from the initial construction and earlier O&M of dams. Mining contamination was determined to be a more serious risk to public health and safety due to the acute and chronic effects of mercury exposure (EPA 2021g). The Pacific Northwest was found to contain lower average mercury concentrations in fish tissue than the rest of the nation (Herger 2016); however, mercury concentrations are frequently reported to be above the Oregon Department of Environmental Quality's (ODEQ) human health water quality criteria for toxic pollutants (Table 3.18-5) (Hillwig and Farrer 2016; ODEQ 2015; ODEQ 2021c). Oregon has a state-wide consumption advisory on bass fish because of mercury contamination, as well as more detailed advisories based on the consumer's age, water body, and type of fish (Table 3.18-6) (OHA No Date-b). Therefore, effects would be state-wide in extent. Of all the contamination in the WVS, mercury is the largest threat to public health and safety, not only due to its neurotoxicity, but because it can be found in fish tissue, to which the public is more exposed than to other contaminants. Because the risk to public health and safety would range from measurable but below regulatory standards, to near regulatory standards depending on quantity, type, and origin of fish consumed, effects would be adverse and minor to moderate in magnitude.

**Table 3.18-5. Oregon Mercury Fish Tissue Concentrations Found in Bass Compared to the Health Criteria**

| | Mercury Concentration(s) |
|---|---|
| Statewide range found in Oregon bass fish[1] | 0.08 to 0.86 (mg/kg) |
| Oregon ODEQ Health Criteria[2] | .04 (mg/kg) |

[1]Data reported by the OHA from Hillwig and Farrer 2016; ODEQ 2015 and reported in mg of total mercury per kg of fish tissue.

[2]Data from ODEQ 2021d, reported in mg of methylmercury per kg of fish tissue.

**Table 3.18-6. Oregon Health Authority Fish Advisories and Consumption Guidelines[2]**

| Area | Contaminant | Affected Fish | Meals per Month | |
|---|---|---|---|---|
| | | | Vulnerable populations | Everyone Else |
| Lower Willamette River | PCB[1] | All fish | Dependent on fish type | Dependent on fish type |
| Cottage Grove Reservoir | Mercury[3] | All fish except stocked rainbow trout < 12 inches | 0 | 4 |
| Dorena Reservoir | Mercury[3] | All fish except stocked rainbow trout < 12 inches | 1 | 4 |
| Willamette River (from the Columbia River to Eugene) | Mercury[3] | All fish | 1 | 4 |

[1]PCBs are considered by OHA to be polychlorinated biphenyls, dioxins, and certain pesticides.

[2]Data from OHA No Date-b.

[3]Methylmercury

The other primary source of WVS legacy contamination is waste from the initial construction and previous O&M of dams. Contaminants such as petroleum, solvents, metals, and PCBs exist at historic disposal sites throughout several of the USACE projects, which are summarized in above in the affected environment (Table 3.18-2). All of these sites have had at least preliminary investigations completed. Their statuses range from “sampling suggests no risks to downstream communities” and “contaminants not detected above residential remediation goals” to “further investigation recommended”. Although no sites have public health risk levels high enough to warrant listing on the NPL, the mere presence of contamination poses a “non-zero” risk to public health and safety. This risk is reduced by using administrative controls such as signage, security patrols, and fencing, which would discourage and restrict access to areas where the public could come into contact with contamination.

Overall, the effects would be negligible to minor in magnitude, adverse, local in extent, in the short, medium, and long term due to ongoing operation, maintenance, repair, replacement, and rehabilitation; and effects would be minor to moderate in magnitude, adverse, and statewide in extent due to Oregon’s mercury contamination.

##### *3.18.2.4.1 Climate Change*

Climate change presents indirect risks to public health and safety from HTRW. Climate change is expected to exacerbate the frequency and severity of natural disasters such as wildland fires and floods. Increasing the severity of fires and floods could compromise contamination sites, and hazardous waste storage facilities to a lesser degree. Fires could make contaminants, especially volatile compounds like solvents and some forms of petroleum, airborne, which would increase the potential for public exposure. Fires could also potentially destroy hazardous waste management infrastructure, such as buildings and containers, and expose waste to the elements. Floods and fires could both spread and expose contamination that had previously not been a risk to the public. However, flooding is a larger concern in tidally-influenced areas, and the WVS is not tidally-influenced. Further, the WVS waste-storage facilities (at Detroit, Fall Creek, and Foster dams) are fire-rated, and BMPs are used to minimize the risk of fires spreading to the facilities, such as trimming tree limbs 30 feet from structures and six feet from the ground. Effects from climate change on public health and safety from HTRW would be negligible to minor in magnitude, adverse, regional in extent, and long-term in duration.

#### ***3.18.2.5 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures***

Under Alternative 1, basin-wide effects from operation, maintenance, repair, replacement, and rehabilitation would be negligible in magnitude, local in extent, adverse, and short- and long-term for routine/scheduled maintenance; and be negligible to minor in magnitude depending on the activity, local in extent, adverse, and medium- and long-term in duration for major maintenance and rehabilitation. Effects from providing Pacific lamprey passage and infrastructure at Fern Ridge and Green Peter would be negligible in magnitude, local in extent, adverse, and short-term in duration. Effects from improving the fish ladder at Foster Dam, and improving structures to reduce TDG at Cougar, Dexter, and Foster would be negligible in magnitude, local in extent, adverse, and medium-term in duration. Effects from constructing a WTC tower at Detroit, Green Peter, and Lookout Point, constructing structural downstream fish passage at Detroit, Foster, and Lookout Point, and constructing an AFF at Green Peter would be negligible in magnitude, local in extent, and adverse in both the medium and long term.

These effects would be greater than Alternatives 2a, 2b, 3a, 3b, and 5, but less than Alternative 4 due to the number of construction measures with medium- and long-term effects.

##### *3.18.2.5.1 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide. As discussed above in Section 3.18.2.3.1, potential effects would be negligible in magnitude, local in extent, adverse, and short- and long-term for routine/scheduled maintenance; and be negligible to minor in magnitude depending on the activity, local in extent, adverse, and medium- and long-term in duration for major maintenance and rehabilitation.

##### *3.18.2.5.2 Provide Pacific lamprey passage and infrastructure (#52)*

Under Alternative 1, providing Pacific lamprey passage and infrastructure would occur at Fern Ridge and Green Peter. As discussed above in Section 3.18.2.3.2, potential effects would be negligible in magnitude, local in extent, adverse, and short-term in duration.

##### *3.18.2.5.3 Foster Fish Ladder Temperature Improvement (#479) and Structural improvements to reduce total dissolved gas (#174)*

Under Alternative 1, improving the fish ladder would occur at Foster Dam and improving structures to reduce TDG would occur at Cougar, Detroit, Dexter, Foster, Green Peter, and Lookout Point (but would only have effects at Cougar, Dexter, and Foster due to the WTC towers). As discussed above in Section 3.18.2.3.3, effects would be negligible in magnitude, local in extent, adverse, and medium-term in duration.

##### *3.18.2.5.4 Construct water temperature control tower (#105), Construct structural downstream fish passage (#392), and Construct adult fish facility (#722)*

Under Alternative 1, constructing a WTC tower would occur at Detroit, Green Peter, and Lookout Point, constructing structural downstream fish passage would occur at Detroit, Foster, Green Peter, and Lookout Point, and constructing an AFF would occur at Green Peter. As discussed above in Section 3.18.2.3.4, effects would be negligible in magnitude, local in extent, and adverse in both the medium and long term.

##### *3.18.2.5.5 Climate Change*

Alternative 1 would combine storage-focused measures in order to improve fish passage. These measures would only have negligible adverse effects on public health and safety from HTRW. Climate change would exacerbate effects, but they would not be appreciably larger than those described under the NAA above in Section 3.18.2.4.1. Therefore, the effects from climate change and Alternative 1 on public health and safety from HTRW would be negligible to minor in magnitude, adverse, regional in extent, and long-term in duration.

#### ***3.18.2.6 Alternative 2a – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam)***

Under Alternative 2a, basin-wide effects from operation, maintenance, repair, replacement, and rehabilitation would be negligible in magnitude, local in extent, adverse, and short- and long-term for routine/scheduled maintenance; and be negligible to minor in magnitude depending on the activity, local in extent, adverse, and medium- and long-term in duration for major maintenance and rehabilitation. Effects from providing Pacific lamprey passage and infrastructure at Green Peter would be negligible in magnitude, local in extent, adverse, and short-term in duration. Effects from improving the fish ladder at Foster and constructing an AFF at Green Peter would be negligible in magnitude, local in extent, adverse, and medium-term in duration. Effects from constructing a WTC tower at Detroit and constructing structural downstream fish passage at Cougar, Detroit, Foster, and Lookout Point would be negligible in magnitude, local in extent, and adverse in both the medium and long term. Effects from the deeper fall reservoir drawdown at Green Peter would be negligible in magnitude, local in extent, and adverse in the long term. The effects from the suite of near-term operations at Green Peter and Lookout Point dams would be negligible in magnitude, local in extent, and adverse in the long term.

These effects would be greater than Alternatives 2b and 5, but less than Alternatives 1, 3a, 3b, and 4 due to the number of construction measures with medium- and long-term effects.

###### *3.18.2.6.1 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide. As discussed above in Section 3.18.2.3.1, potential effects would be negligible in magnitude, local in extent, adverse, and short- and long-term for routine/scheduled maintenance; and be negligible to minor in magnitude depending on the activity, local in extent, adverse, and medium- and long-term in duration for major maintenance and rehabilitation.

###### *3.18.2.6.2 Provide Pacific lamprey passage and infrastructure (#52)*

Under Alternative 2a, providing Pacific lamprey passage and infrastructure would occur at Green Peter. As discussed above in Section 3.18.2.3.2, potential effects would be negligible in magnitude, local in extent, adverse, and short-term in duration.

###### *3.18.2.6.3 Foster Fish Ladder Temperature Improvement (#479)*

Under Alternative 2a, improving the fish ladder would occur at Foster Dam. As discussed above in Section 3.18.2.3.3, effects would be negligible in magnitude, local in extent, adverse, and medium-term in duration.

###### *3.18.2.6.4 Construct water temperature control tower (#105), Construct structural downstream fish passage (#392), and Construct adult fish facility (#722)*

Under Alternative 2a, constructing a WTC tower would occur at Detroit, constructing structural downstream fish passage would occur at Cougar, Detroit, Foster, and Lookout Point, and constructing an AFF would occur at Green Peter. As discussed above in Section 3.18.2.3.4, effects would be negligible in magnitude, local in extent, and adverse in both the medium and long term.

###### *3.18.2.6.5 Deeper fall reservoir drawdowns for fish passage (#40)*

Under Alternative 2a, deeper fall reservoir drawdowns for downstream fish passage would occur at Green Peter. As discussed above in Section 3.18.2.3.5, effects would be negligible in magnitude, local in extent, and adverse in the long term.

##### *3.18.2.6.6 Suite of Near-term Operations*

As discussed in Section 3.18.2.3.6, the majority of the near-term operations involve water-management operations, and thus, would not have effects on public health and safety from HTRW. The deep drawdowns at Green Peter and Lookout Point dams would each require the installation of an EDG and would generate small amounts of hazardous waste; therefore, the effects would be negligible in magnitude, local in extent, and adverse in the long term.

##### *3.18.2.6.7 Climate Change*

Alternative 2a would integrate water management flexibility and ESA-listed fish measures (using structural downstream passage at Cougar Dam). These measures would only have negligible adverse effects on public health and safety from HTRW. Climate change would exacerbate effects, but they would not be appreciably larger than those described under the NAA above in Section 3.18.2.4.1. Therefore, the effects from climate change and Alternative 2a on public health and safety from HTRW would be negligible to minor in magnitude, adverse, regional in extent, and long-term in duration.

#### ***3.18.2.7 Alternative 2b – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)***

Under Alternative 2b, basin-wide effects from operation, maintenance, repair, replacement, and rehabilitation would be negligible in magnitude, local in extent, adverse, and short- and long-term for routine/scheduled maintenance; and be negligible to minor in magnitude depending on the activity, local in extent, adverse, and medium- and long-term in duration for major maintenance and rehabilitation. Effects from providing Pacific lamprey passage and infrastructure at Green Peter would be negligible in magnitude, local in extent, adverse, and short-term in duration. Effects from improving the fish ladder at Foster would be negligible in magnitude, local in extent, adverse, and medium-term in duration. Effects from constructing a WTC tower at Detroit, constructing structural downstream fish passage at Detroit, Foster, and Lookout Point, and constructing an AFF at Green Peter would be negligible in magnitude, local in extent, and adverse in both the medium and long term. Effects from the deeper fall reservoir drawdown would be negligible in magnitude, local in extent, and adverse in the long term at Green Peter, and in the medium and long term at Cougar. The effects from the suite of near-term operations at Green Peter and Lookout Point would be negligible in magnitude, local in extent, and adverse in the long term.

These effects would be the same as Alternative 5 and less than all other action alternatives due to the number of construction activities with medium- and long-term effects.

##### *3.18.2.7.1 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide. As discussed above in Section 3.18.2.3.1, potential effects would be negligible in magnitude, local in extent, adverse, and short- and long-term for routine/scheduled maintenance; and be negligible to minor in magnitude depending on the activity, local in extent, adverse, and medium- and long-term in duration for major maintenance and rehabilitation.

###### *3.18.2.7.2 Provide Pacific lamprey passage and infrastructure (#52)*

Under Alternative 2b, providing Pacific lamprey passage and infrastructure would occur at Green Peter. As discussed above in Section 3.18.2.3.2, potential effects would be negligible in magnitude, local in extent, adverse, and short-term in duration.

###### *3.18.2.7.3 Foster Fish Ladder Temperature Improvement (#479)*

Under Alternative 2b, improving the fish ladder would occur at Foster Dam. As discussed above in Section 3.18.2.3.3, effects would be negligible in magnitude, local in extent, adverse, and medium-term in duration.

###### *3.18.2.7.4 Construct water temperature control tower (#105), Construct structural downstream fish passage (#392), and Construct adult fish facility (#722)*

Under Alternative 2b, constructing a WTC tower would occur at Detroit, constructing structural downstream fish passage would occur at Detroit, Foster, and Lookout Point and constructing an AFF would occur at Green Peter. As discussed above in Section 3.18.2.3.4, effects would be negligible in magnitude, local in extent, and adverse in both the medium and long term.

###### *3.18.2.7.5 Deeper fall reservoir drawdowns for fish passage (#40)*

Under Alternative 2b, deeper fall reservoir drawdowns for downstream fish passage would occur at Cougar and Green Peter. As discussed above in Section 3.18.2.3.5, effects would be negligible in magnitude, local in extent, and adverse in the medium and long term.

###### *3.18.2.7.6 Suite of Near-term Operations*

As discussed in Section 3.18.2.3.6, the majority of the near-term operations involve water-management operations, and thus, would not have effects on public health and safety from HTRW. The deep drawdowns at Green Peter and Lookout Point dams would each require the installation of an EDG and would generate small amounts of hazardous waste; therefore, the effects would be negligible in magnitude, local in extent, and adverse in the long term.

###### *3.18.2.7.7 Climate Change*

Alternative 2b would integrate water management flexibility and ESA-listed fish measures (using a deep drawdown to Cougar Dam’s DT). These measures would only have negligible adverse effects on public health and safety from HTRW. Climate change would exacerbate effects, but they would not be appreciably larger than those described under the NAA above in Section 3.18.2.4.1. Therefore, the effects from climate change and Alternative 2b on public health and safety from HTRW would be negligible to minor in magnitude, adverse, regional in extent, and long-term in duration.

#### *3.18.2.8 Alternative 3a – Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)*

Under Alternative 3a, basin-wide effects from operation, maintenance, repair, replacement, and rehabilitation would be negligible in magnitude, local in extent, adverse, and short- and long-term for routine/scheduled maintenance; and be negligible to minor in magnitude depending on the activity, local in extent, adverse, and medium- and long-term in duration for major maintenance and rehabilitation. Effects from using the spillway for surface spill in the summer would occur at Blue River and Hills Creek, and effects from providing Pacific lamprey passage and infrastructure at Blue River, Green Peter, and Hills Creek would be negligible in magnitude, local in extent, adverse, and short-term in duration. Effects from constructing AFFs at Blue River, Green Peter, and Hills Creek would be negligible in magnitude, local in extent, adverse, and medium- and long-term in duration. Effects from the deeper fall reservoir drawdowns would be negligible in magnitude, local in extent, and adverse in the long term at Detroit, Green Peter, and Lookout Point. The deeper fall drawdowns would also have minor in magnitude, local in extent, adverse, short-term and long-term recurring effects at Blue River. The effects from the suite of near-term operations at Green Peter and Lookout Point would be negligible in magnitude, local in extent, and adverse in the long term.

These effects would be greater than Alternatives 2a, 2b, and 5, but less than Alternatives 1, 3b, and 4 due to the quantity of oil-filled equipment that would need to be installed for deeper drawdowns.

##### *3.18.2.8.1 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide. As discussed above in Section 3.18.2.3.1, potential effects would be negligible in magnitude, local in extent, adverse, and short- and long-term for routine/scheduled maintenance; and be negligible to minor in magnitude depending on the activity, local in extent, adverse, and medium- and long-term in duration for major maintenance and rehabilitation.

##### *3.18.2.8.2 Use spillway for surface spill in summer (#721) and Provide Pacific lamprey passage and infrastructure (#52)*

Under Alternative 3a, using the spillway for surface spill in the summer would occur at Blue River, Detroit, Foster, Green Peter, Hills Creek, and Lookout Point (but would only have effects at Blue River and Hills Creek due to structural improvements), and providing Pacific lamprey passage and infrastructure would occur at Blue River, Green Peter, and Hills Creek. As discussed above in Section 3.18.2.3.2, potential effects would be negligible in magnitude, local in extent, adverse, and short-term in duration.

#### *3.18.2.8.3 Construct adult fish facility (#722)*

Under Alternative 3a, constructing an AFF would occur at Blue River, Green Peter, and Hills Creek. As discussed above in Section 3.18.2.3.4, effects would be negligible in magnitude, local in extent, adverse, and medium- and long-term in duration.

#### *3.18.2.8.4 Deeper fall reservoir drawdowns for fish passage (#40)*

Under Alternative 3a, deeper fall reservoir drawdowns for downstream fish passage would occur at Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point (but would only have effects at Detroit, Green Peter, and Lookout Point due to the installation of EDGs, and at Blue River, due to the legacy contamination). As discussed above in Section 3.18.2.3.5, effects would be negligible in magnitude, local in extent, and adverse in the long term at Detroit, Green Peter, and Lookout Point. Effects would be minor in magnitude, local in extent, and adverse in the short term and recurring in the long term at Blue River.

#### *3.18.2.8.5 Suite of Near-term Operations*

As discussed in Section 3.18.2.3.6, the majority of the near-term operations involve water-management operations, and thus, would not have effects on public health and safety from HTRW. The deep drawdowns at Green Peter and Lookout Point dams would each require the installation of an EDG and would generate small amounts of hazardous waste; therefore, the effects would be negligible in magnitude, local in extent, and adverse in the long term.

#### *3.18.2.8.6 Climate Change*

Alternative 3a would improve fish passage by using operations-focused measures (using a deep drawdown to Cougars Dam's RO). These measures would only have negligible adverse effects on public health and safety from HTRW. Climate change would exacerbate effects, but they would not be appreciably larger than those described under the NAA above in Section 3.18.2.4.1. Therefore, the effects from climate change and Alternative 3a on public health and safety from HTRW would be negligible to minor in magnitude, adverse, regional in extent, and long-term in duration.

### ***3.18.2.9 Alternative 3b – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)***

Under Alternative 3b, basin-wide effects from operation, maintenance, repair, replacement, and rehabilitation would be negligible in magnitude, local in extent, adverse, and short- and long-term for routine/scheduled maintenance; and be negligible to minor in magnitude depending on the activity, local in extent, adverse, and medium- and long-term in duration for major maintenance and rehabilitation. Effects from using the spillway for surface spill in the summer would occur at Blue River and Hills Creek, and effects from providing Pacific lamprey passage and infrastructure at Blue River, Green Peter, and Hills Creek would be negligible in magnitude, local in extent, adverse, and short-term in duration. Effects from constructing an

AFF at Blue River, Green Peter, and Hills Creek would be negligible in magnitude, local in extent, adverse, and medium- and long-term in duration. Effects from the deeper fall reservoir drawdowns would be negligible in magnitude, local in extent, and adverse in the medium and long term at Cougar and in the long term at Detroit, Green Peter, and Lookout Point. The deeper fall drawdowns would also have minor in magnitude, local in extent, adverse, short-term and long-term recurring effects at Blue River. The effects from the suite of near-term operations at Green Peter and Lookout Point would be negligible in magnitude, local in extent, and adverse in the long term.

These effects would be greater than Alternatives 2a, 2b, 3a, and 5, but less than Alternatives 1 and 4 due to the quantity of oil-filled equipment that would need to be installed for deeper drawdowns.

##### *3.18.2.9.1 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide. As discussed above in Section 3.18.2.3.1, potential effects would be negligible in magnitude, local in extent, adverse, and short- and long-term for routine/scheduled maintenance; and be negligible to minor in magnitude depending on the activity, local in extent, adverse, and medium- and long-term in duration for major maintenance and rehabilitation.

##### *3.18.2.9.2 Use spillway for surface spill in summer (#721) and Provide Pacific lamprey passage and infrastructure (#52)*

Under Alternative 3b, using the spillway for surface spill in the summer would occur at Blue River, Detroit, Foster, Green Peter, Hills Creek, and Lookout Point (but would only have effects at Blue River and Hills Creek due to structural improvements), and providing Pacific lamprey passage and infrastructure would occur at Blue River, Green Peter, and Hills Creek. As discussed above in Section 3.18.2.3.2, potential effects would be negligible in magnitude, local in extent, adverse, and short-term in duration.

##### *3.18.2.9.3 Construct adult fish facility (#722)*

Under Alternative 3b, constructing an AFF would occur at Blue River, Green Peter, and Hills Creek. As discussed above in Section 3.18.2.3.4, effects would be negligible in magnitude, local in extent, adverse, and medium- and long-term in duration.

##### *3.18.2.9.4 Deeper fall reservoir drawdowns for fish passage (#40)*

Under Alternative 3b, deeper fall reservoir drawdowns for downstream fish passage would occur at Blue River, Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point (but would only have effects at Blue River, Cougar, Detroit, Green Peter, and Lookout Point due to construction, legacy contamination and installation of EDGs). As discussed above in Section 3.18.2.3.5, effects would be negligible in magnitude, local in extent, and adverse in the medium and long term at

Cougar, and long term at Detroit, Green Peter, and Lookout Point. Effects would be minor in magnitude, local in extent, adverse in the short term and recurring in the long term at Blue River.

#### *3.18.2.9.5 Suite of Near-term Operations*

As discussed in Section 3.18.2.3.6, the majority of the near-term operations involve water-management operations, and thus, would not have effects on public health and safety from HTRW. The deep drawdowns at Green Peter and Lookout Point dams would each require the installation of an EDG and would generate small amounts of hazardous waste; therefore, the effects would be negligible in magnitude, local in extent, and adverse in the long term.

#### *3.18.2.9.6 Climate Change*

Alternative 3b would improve fish passage by using operations-focused measures (using a deep drawdown to Cougars Dam's DT). These measures would only have negligible adverse effects on public health and safety from HTRW. Climate change would exacerbate effects, but they would not be appreciably larger than those described under the NAA above in Section 3.18.2.4.1. Therefore, the effects from climate change and Alternative 3a on public health and safety from HTRW would be negligible to minor in magnitude, adverse, regional in extent, and long-term in duration.

### ***3.18.2.10 Alternative 4 – Improve Fish Passage with Structures-Based Approach***

Under Alternative 4, basin-wide effects from operation, maintenance, repair, replacement, and rehabilitation would be negligible in magnitude, local in extent, adverse, and short- and long-term for routine/scheduled maintenance; and be negligible to minor in magnitude depending on the activity, local in extent, adverse, and medium- and long-term in duration for major maintenance and rehabilitation. Effects from providing Pacific lamprey passage and infrastructure at Fern Ridge and Hills Creek would be negligible in magnitude, local in extent, adverse, and short-term in duration. Effects from improving the fish ladder at Foster Dam and improving structures to reduce TDG at Cougar, Dexter, Foster, and Green Peter would be negligible in magnitude, local in extent, adverse, and medium-term in duration. Effects from constructing a WTC tower at Detroit, Hills Creek, and Lookout Point, constructing structural downstream fish passage at Cougar, Detroit, Foster, Hills Creek, and Lookout Point, and constructing an AFF at Green Peter would be negligible in magnitude, local in extent, and adverse in both the medium and long term. The effects from the suite of near-term operations at Green Peter and Lookout Point would be negligible in magnitude, local in extent, and adverse in the long term.

These effects would be greater than Alternatives 1, 2a, 2b, 3a, 3b, and 5 due to the number of construction activities with medium- and long-term effects.

###### *3.18.2.10.1 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Under all action alternatives, operation, maintenance, repair, replacement, and rehabilitation would occur basin-wide. As discussed above in Section 3.18.2.3.1, potential effects negligible in magnitude, local in extent, adverse, and short- and long-term for routine/scheduled maintenance; and be negligible to minor in magnitude depending on the activity, local in extent, adverse, and medium- and long-term in duration for major maintenance and rehabilitation.

###### *3.18.2.10.2 Provide Pacific lamprey passage and infrastructure (#52)*

Under Alternative 4, providing Pacific lamprey passage and infrastructure would occur at Fern Ridge and Hills Creek. As discussed above in Section 3.18.2.3.2, potential effects would be negligible in magnitude, local in extent, adverse, and short-term in duration.

###### *3.18.2.10.3 Foster Fish Ladder Temperature Improvement (#479) and Structural improvements to reduce total dissolved gas (#174)*

Under Alternative 4, improving the fish ladder would occur at Foster Dam and improving structures to reduce TDG would occur at Cougar, Detroit, Dexter, Foster, Green Peter, and Lookout Point (but would only have effects at Cougar, Dexter, Foster, and Green Peter due to the WTC towers). As discussed above in Section 3.18.2.3.3, effects would be negligible in magnitude, local in extent, adverse, and medium-term in duration.

###### *3.18.2.10.4 Construct water temperature control tower (#105), Construct structural downstream fish passage (#392), and Construct adult fish facility (#722)*

Under Alternative 4, constructing a WTC tower would occur at Detroit, Hills Creek, and Lookout Point, constructing structural downstream fish passage would occur at Cougar, Detroit, Foster, Hills Creek, and Lookout Point, and constructing an AFF would occur at Hills Creek. As discussed above in Section 3.18.2.3.4, effects would be negligible in magnitude, local in extent, and adverse in both the medium and long term.

###### *3.18.2.10.5 Suite of Near-term Operations*

As discussed in Section 3.18.2.3.6, the majority of the near-term operations involve water-management operations, and thus, would not have effects on public health and safety from HTRW. The deep drawdowns at Green Peter and Lookout Point dams would each require the installation of an EDG and would generate small amounts of hazardous waste; therefore, the effects would be negligible in magnitude, local in extent, and adverse in the long term.

###### *3.18.2.10.6 Climate Change*

Alternative 4 would improve fish passage with structures-based measures. These measures would only have negligible adverse effects on public health and safety from HTRW. Climate change would exacerbate effects, but they would not be appreciably larger than those described under the NAA above in Section 3.18.2.4.1. Therefore, the effects from climate change and Alternative 4 on public health and safety from HTRW would be negligible to minor in magnitude, adverse, regional in extent, and long-term in duration.

#### *3.18.2.11 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 5 is similar to Alternative 2b but includes the *refined* integrated habitat and flow regime (#30b), rather than the integrated habitat and flow regime (#30a). This measure would not have adverse effects to public health and safety from HTRW. Therefore, the effects would be identical to Alternative 2b: less than all other action alternatives.

#### *3.18.2.12 Conclusion*

Severity of adverse effects on public health and safety from HTRW is primarily driven by the number of medium-term construction projects, and secondarily by the number of measures that would require the installation of oil-filled equipment and subsequently result in long-term effects. The action alternatives organized in order of least-severe to most-severe adverse effects on hazardous materials would be: 2b/5, 2a, 3a, 3b, 1, and 4. Differences between the action alternatives would not contribute to effects from climate change on public health and safety from HTRW. Therefore, all action alternatives would result in approximately equal effects from climate change with respect to public health and safety from HTRW.

## 3.19 PUBLIC HEALTH AND SAFETY – DRINKING WATER

### 3.19.1 Affected Environment

This section discusses the importance of protecting drinking water resources for public health and the federal and state regulatory requirements for drinking water. Groundwater and surface water sources that communities rely on for public drinking water are located downstream of the WVS reservoirs. The City of Monroe relies on drinking water from the Long Tom River where the Fern Ridge reservoir is located. The City of Cottage Grove receives drinking water from Row River, which is downstream of the Dorena Reservoir. The City of Sweet Home receives irrigation water from Foster Reservoir. The cities of Salem, Eugene, and Springfield all receive drinking water from downstream of the WVS reservoirs. Lastly the City of Lowell relies on drinking water directly from the Dexter Reservoir. The water sourced from downstream of the reservoirs or directly from the reservoirs is treated by a combination of filtration, aeration, and disinfection at a public water treatment facility before it is distributed.

### 3.19.2 Drinking Water Regulatory Background

The proper treatment, disinfection, and distribution of clean drinking water is vital to the prevention of public health risks in the WVS. Contamination of drinking water sources can be caused by pesticides, animal waste, improper disposal of chemicals, and naturally-occurring substances within the watershed. Drinking water that has not been treated or a distribution system that needs maintenance can also pose health risks. Federal drinking water regulations and Oregon state rules and guidelines protect drinking water sources, including lakes, rivers, springs, and groundwater wells.

The federal Safe Drinking Water Act (SDWA) was passed in 1974 to protect national public drinking water sources including groundwater and surface waters such as rivers, lakes, streams, reservoirs, springs, ponds, and wells. The SDWA authorizes the U.S. Environmental Protection Agency (EPA) to set standards for drinking water. The SDWA originally set forth standards for safe drinking water in tap water. The 1996 amendment set further protections for source water at drinking water reservoirs, as well as operator training and funding for water system projects (EPA 2004).

Water can dissolve substances from human activities or animals as it runs over land or through the ground and drains to drinking water sources. Containments that can be found in drinking water include microbial contaminants such as viruses and bacteria, inorganic contaminants such as salts and metals, pesticides and herbicides, chemicals, and radioactive contaminants which may be naturally occurring (City of Sweet Home Public Works 2021). Metals including iron and manganese are found to be in high concentrations in instream waters downstream of reservoirs as well as excessive nutrients such as nitrogen and phosphorus which can cause algal blooms (Kennedy & Gaugush 1988). Some algal blooms are harmful if people or pets come in contact with polluted water or consume tainted fish or shellfish (EPA 2022d). See Section 3.17.1 Harmful Algal Blooms.

The EPA drinking water standards regulate over 90 contaminants. These standards are grouped in two categories: the National Primary Drinking Water Regulations (NPDWR or primary standards) and the National Secondary Drinking Water Regulations (NSDWR or secondary standards). Primary drinking water standards are legally enforceable. The primary standards set mandatory water quality standards or “maximum contaminant levels” (MCLs) to protect the public against drinking water contaminants. Secondary standards are non-enforceable and provide guidelines for aesthetic considerations such as taste, color, and odor (EPA 2021h). Table 3.19-1 include a partial list of contaminants regulated by the NPDWR and Table 3.19-2 lists the NSDWR.

**Table 3.19-1. Partial list of contaminants regulated under National Primary Drinking Water Regulations (EPA 2022a)**

| Contaminant | MCLG (mg/L) | Potential Health Effects from Long-Term Exposure Above the MCL (unless specified as short-term) | Sources of Contaminant in Drinking Water |
|---|---|---|---|
| Cryptosporidium | zero | Gastrointestinal illness (such as diarrhea, vomiting, and cramps) | Human and animal fecal waste |
| *Giardia lamblia* | zero | Gastrointestinal illness (such as diarrhea, vomiting, and cramps) | Human and animal fecal waste |
| *Legionella* | zero | Legionnaire's Disease, a type of pneumonia | Found naturally in water; multiplies in heating systems |
| Total Coliforms (including fecal coliform and *E. Coli*) | zero | Not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present | Coliforms are naturally present in the environment; as well as feces; fecal coliforms and E. coli only come from human and animal fecal waste. |
| Turbidity | na | Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (such as whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria. These organisms can cause symptoms such as | Soil runoff |

| Contaminant | MCLG (mg/L) | Potential Health Effects from Long-Term Exposure Above the MCL (unless specified as short-term) | Sources of Contaminant in Drinking Water |
|---|---|---|---|
| | | nausea, cramps, diarrhea, and associated headaches. | |
| Viruses (enteric) | zero | Gastrointestinal illness (such as diarrhea, vomiting, and cramps) | Human and animal fecal waste |
| Chlorite | 0.8 | Anemia; infants and young children: nervous system effects | Byproduct of drinking water disinfection |
| Chloramines (as Cl2) | MRDLG=41 | Eye/nose irritation; stomach discomfort, anemia | Water additive used to control microbes |
| Chlorine (as Cl2) | MRDLG=41 | Eye/nose irritation; stomach discomfort | Water additive used to control microbes |
| Asbestos (fiber > 10 micrometers) | 7 million fibers per liter (MFL) | Increased risk of developing benign intestinal polyps | Increased risk of developing benign intestinal polyps |
| Cyanide (as free cyanide) | 0.2 | Nerve damage or thyroid problems | Discharge from steel/metal factories; discharge from plastic and fertilizer factories |
| Lead | zero | Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities<br>Adults: Kidney problems; high blood pressure | Corrosion of household plumbing systems; erosion of natural deposits |
| Nitrate (measured as Nitrogen) | 10 | Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome. | Runoff from fertilizer use; leaking from septic tanks, sewage; erosion of natural deposits |
| Nitrite (measured as Nitrogen) | 1 | Infants below the age of six months who drink water containing nitrite in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome. | Runoff from fertilizer use; leaking from septic tanks, sewage; erosion of natural deposits |

| Contaminant | MCLG (mg/L) | Potential Health Effects from Long-Term Exposure Above the MCL (unless specified as short-term) | Sources of Contaminant in Drinking Water |
|---|---|---|---|
| Glyphosate | 0.7 | Kidney problems; reproductive difficulties | Runoff from herbicide use |

[1]Maximum Residual Disinfectant Level Goal (MRDLG) - The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.

**Table 3.19-2. List of National Secondary Drinking Water Regulations (EPA 2022b)**

| Contaminant | Secondary Standard |
|---|---|
| Aluminum | 0.05 to 0.2 mg/L |
| Chloride | 250 mg/L |
| Color | 15 (color units) |
| Copper | 1.0 mg/L |
| Corrosivity | noncorrosive |
| Fluoride | 2.0 mg/L |
| Foaming Agents | 0.5 mg/L |
| Iron | 0.3 mg/L |
| Manganese | 0.05 mg/L |
| Odor | 3 threshold odor number* |
| pH | 6.5-8.5 |
| Silver | 0.10 mg/L |
| Sulfate | 250 mg/L |
| Total Dissolved Solids | 500 mg/L |
| Zinc | 5 mg/L |

*Threshold odor number is the number of dilutions it takes to produce odor free water.

The Surface Water Treatment Rule (SWTR) requires all utilities with a surface water supply, or a groundwater supply influenced by surface water, to provide adequate disinfection to prevent illness from pathogens (EPA 2021i) which include *Legionella*, *Giardia lamblia*, and *Cryptsosporidium*. The Ground Water Rule (GWR) provides protection for ground water sources which can be susceptible to fecal contamination. It applies to public water systems which use groundwater as a drinking water source.

The Oregon Drinking Water Quality Act enacted in 1981 ensures safe drinking water, provides a regulatory program for drinking water, and provides a means to improving inadequate drinking water systems. The rules promote coordination between the programs for supervising water systems which are conducted by the Authority and the EPA (OHA No Date-c). The Oregon Health Authority (OHA) regulates drinking water under Oregon state law and the SDWA and works with ODEQ on drinking water source protection to prevent public health risks. ODEQ works to protect drinking sources by implementing the CWA, identifying the source waters in watersheds and aquifers for surface water and groundwater for public water supply systems, and developing water assessments and guides for community public water systems (ODEQ 2021e).

### 3.19.3 Groundwater and Surface Water

Groundwater is a critical source of drinking water in the state of Oregon where almost half of the population relies on groundwater for daily consumption. Approximately 35 percent of people rely solely on groundwater for drinking water, 10 percent rely on surface water, and 55 percent rely on a combination of both (OHA 2018). This heavy reliance on groundwater is due to the decreasing availability of surface water and higher costs for treating surface water (the proportion of groundwater users in the WRB has not been quantified because it would require researching the source water information for each town or city in the WRB which is beyond the scope of a programmatic document). Groundwater wells can be contaminated by surface pollutants such as microbial contamination, fertilizers and pesticides, and arsenic. Currently, there are approximately 50 public water systems in Oregon that are exposed to groundwater contamination from active chemical cleanup sites (OHA No Date-e).

The DEQ is designated as the lead agency for implementation of the Wellhead Protection Program (WHPP). The WHPP was implemented in order to "protect wellhead areas within their jurisdiction from contaminants which may have any adverse effect on the health of persons" (OHA No Date). The program provides incentives for community participation in the program, provides a detailed guidance manual for local implementation, and promotes public awareness of the impact of land use on drinking water among other initiatives. With the 1996 amendment of the SDWA, states were required to develop Source Water Assessment Programs. As such, Oregon has been working to expand the WHPP to develop a Drinking Water Protection Program that includes surface water sources (OHA No Date-e). Private drinking water wells which serve fewer than 25 people are not regulated by the SDWA (EPA 2022c).

Source water assessments were completed in Oregon in 1999 and 2005 with updates in 2016 and 2017 (OHA 2018). Source water assessments for individual community public water systems which rely on surface water within the WVS can be found on the DEQ website. The assessments indicate the potential contaminant sources within the watershed areas of the water supply. The assessments allow communities to develop strategies to protect drinking water sources based on the land uses within the water supply area and the inventory of potential contaminants (ODEQ 2019b). Strategies for source water protection include mapping source water protection areas, inventorying known and potential contamination sources, and developing action plans to prevent contamination.

Water supply allocations for M&I and agricultural irrigation (AI) have been planned for a 30-year planning horizon to the year 2050. Table 1-6 lists the allocated storage for fish and wildlife, M&I, and AI water supply. In deficit water years, water delivery for AI uses may be ceased or curtailed; however, this would not affect M&I drinking water availability.

### 3.19.4 Monitoring

The ODEQ Laboratory conducted 45 groundwater assessments between 1980 and 2000 and determined the most commonly detected contaminants in Oregon included nitrates, pesticides, and bacteria. The groundwater studies found 35 of the 45 study areas had some impairment. In the Willamette Valley, approximately thirty-three percent of rural water wells contained at least one pesticide from historic uses (DEQ 2017). The Corps commonly uses pesticides such as triclopyr choline and glyphosate for routine maintenance (see further discussion in Section 3.16 Hazardous materials).

If drinking water is found to be contaminated, a water advisory is issued by public water system officials (CDC 2020). The OHA Drinking Water Advisories website posts current drinking water advisories in Oregon. It includes information such as the source of water (surface water or groundwater), the reason for the advisory (i.e., nitrate, *E. coli*, arsenic), and the towns or communities affected (OHA No Date-d).

### 3.19.5 Environmental Effects

This section discusses the potential effects of the Proposed Action and alternatives on Public Health and Safety – Drinking Water. The discussion includes the methodology, the measures within the action alternatives that were analyzed, a summary of the effects, and a detailed analysis for each alternative.

#### *3.19.5.1 Methodology*

The methodology below is used to assess the No Action Alternative (NAA) and the action alternatives' effects on the drinking water quality and supply in the WVS. The measures for the alternatives would cause either adverse effects or be beneficial to the availability and quality of drinking water in the reservoirs. Adverse effects to drinking water as it relates to public health and safety would be caused by a decline in water quality or water supply. Beneficial effects to drinking water as it relates to public health and safety would improve water quality or water supply. The effects to the quality and availability of drinking water could last for several days or up to a year or more and can occur over a small localized area or the entire reservoir and the downstream reaches.

Table 3.19-3 describes the evaluation criteria for the effect factors (magnitude, duration, and extent), and provides a definition for the scale of each effect factor.

**All comparisons of effects for each action alternative are in comparison to the NAA unless stated otherwise.**

**Table 3.19-3. Evaluation Criteria for Potential Effects to Public Health and Safety – Drinking Water**

| Effect Factors and Scale | Definition |
|---|---|
| **Magnitude** | |
| Negligible | Public health and safety would not be affected, or changes or benefits would be either nondetectable or, if detected by monitoring or exposure to pollutants within the drinking water supply, would have slight effects. Chemical or physical changes to water quality would be within regulatory standards for water quality conditions for drinking water. No mitigation measures would be necessary. There would be little or no detectable adverse effects to the availability of drinking water affecting water supply for consumers or beneficial effects to the availability of drinking water resulting in a surplus of water supply |
| Minor | Changes to public health and safety would be measurable if detected by monitoring or exposure to pollutants within the drinking water supply, although the changes would be small. Chemical or physical changes to water quality would be detectable by monitoring or exposure to unsafe drinking water, but would be within regulatory standards for water quality conditions for drinking water. No mitigation measures would be necessary. There would be small detectable adverse effects to the availability of drinking water affecting water supply for consumers or beneficial effects to the availability of drinking water resulting in a surplus of water supply |
| Moderate | Changes to public health and safety would be measurable by monitoring and any increased or decreased exposure to pollutants within the drinking water supply would have adverse /beneficial effects (respectively) on the affected water body and any affected local downstream receiving waters for drinking water. Chemical or physical changes to water quality would be below regulatory standards for water conditions suitable for drinking water. Mitigation measures would be necessary if the affected water body and local downstream receiving waters are used for drinking water. There would be detectable adverse effects to the availability of drinking water affecting water supply for consumers or beneficial effects to the availability of drinking water resulting in a surplus of water supply. |
| Major or Significant | Changes to public health and safety would be readily apparent, either severely adverse or exceptionally beneficial, and result in substantial, noticeable effects on the affected water body and any affected local downstream receiving waters for drinking water. The |

| Effect Factors and Scale | Definition |
|---|---|
| | effects would be detectable by monitoring or exposure to pollutants within the drinking water supply. Chemical or physical changes to water quality would be well below regulatory standards for water quality conditions suitable for drinking water. Mitigation measures would not be sufficient to reduce pollutant levels to an acceptable drinking water quality. There would be detectable adverse effects to the availability of drinking water affecting water supply for consumers or beneficial effects to the availability of drinking water resulting in a surplus of water supply. |
| **Duration** | |
| Short-term | Effects last for the duration of small construction projects and are continuous for less than 2 years. |
| Medium-term | Effects are limited to the duration of large construction projects and are continuous for a period of 2-5 years. |
| Long-term | Effects are permanent or last continuously beyond operational changes or the completion of all construction projects; effects recur at regular intervals (e.g., deep drawdowns that occur for a 3-week period in the fall and/or spring); or effects occur intermittently. |
| **Extent** | |
| Small | Effects would be confined to a small area (e.g., the inflow to the dam, the area surrounding the principal inlet, along the shoreline of the reservoir, downstream of the dam, or the project area). |
| Medium | Effects occur in the entire reservoir. |
| Large | Effects occur in the entire reservoir and downstream receiving water body. |

#### *3.19.5.2 Measures Analyzed for Public Health and Safety – Drinking Water*

Measures under the action alternatives that could impact Public Health and Safety – Drinking Water include:

- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9);
- Fall Creek drawdown;
- Operation, maintenance, repair, replacement, and rehabilitation;
- Foster fish ladder temperature improvement (#479);
- Construct water temperature control (WTC) towers (#105);

- Use regulating outlets (ROs) to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166);
- Use spillway for surface spill in summer (#721);
- Structural improvements to reduce total dissolved gas (#174);
- Augment instream flows by using the inactive pool (#718);
- Augment instream flows by using the power pool (#304);
- Reduce minimum flows to Congressionally authorized minimum flow requirements (#723);
- Integrated temperature and habitat flow regime (#30a);
- Refined integrated temperature and habitat flow regime (#30b)
- Restore upstream and downstream passage at drop structures (#639);
- Construct adult fish facility (AFF) (#722);
- Provide Pacific lamprey passage and infrastructure (#52);
- Construct structural downstream fish passage (#392);
- Deeper fall reservoir drawdowns for fish passage (#40);
- Spring reservoir drawdown for fish downstream fish passage (#720); and
- Pass water over spillway in spring for fish passage (#714).

The following measures would have no effect on Public Health and Safety – Drinking Water and are therefore not discussed further.

- Gravel augmentation below dams (#384);
- Adapt hatchery program (#719);
- Maintenance of existing and new fish release sites above dams (#726).
- Continued operation of existing adult fish facilities;

A summary of the Public Health and Safety – Drinking Water effects discussed in the sections below is provided in Table 3.19-4.

Note that where a range of potential effects would occur, the most severe magnitude of adverse effects and the least magnitude of beneficial effects for each alternative is listed to present the most conservative range of potential effects. Also, the extent of effects includes all reservoirs where potential effects would occur, even if the most severe adverse effect or the least beneficial effect does not occur at that reservoir. Discussion of all adverse and beneficial effects is presented below.

**Table 3.19-4. Summary of Effects to Public Health and Safety – Drinking Water Under Each Alternative**

| Effect Factor | | Alternative | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NAA | 1 | 2A | 2B | 3A | 3B | 4 | 5 |
| | **Short-Term** | | | | | | | |
| Magnitude | Minor beneficial and adverse | Minor adverse; Minor beneficial | Minor beneficial and/or adverse | Minor beneficial and/or adverse | Minor beneficial and/or adverse | Minor beneficial and/or adverse | Minor beneficial and/or adverse | Minor beneficial and/or adverse |
| Extent | Large (basin-wide, FOS, DET, FCR, CGR, DEX, BCL, LOP, HCR, GPR) | Small, large (basin-wide, BLU, CTG, DOR, FCR; CGR, DET, GPR, HCR, LOP) | Small, large (basin-wide, GRP, BLUE, FCR, CGR, DET, HCR, LOP, FOS, BCL) | Small, large (basin-wide, FCR, BLU, FCR, CGR, LOP, FCR, HCR, CGR, FOS, BCL, DET) | Small, large (basin-wide; DET, GPR, LOP, BLU, FOS, HCR, CTG, DOR, FCR, CGR, BCL) | Small, large (basin-wide; DET, GPR, LOP, BLU, FOS, HCR, CTG, DOR, FCR, CGR, BCL) | Small, large (basin-wide, GPR, BLU, CTG, DOR, FCR, CGR, DET, GPR, HCR, LOP, BCL) | Small, large (basin-wide, GRP, BLU, FCR, DET, GPR, HCR, LOP, BCL, CGR, FOS, BCL) |
| | **Medium-Term** | | | | | | | |
| Magnitude | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse |
| Extent | Small (basin-wide) | Small, large (FOS, DET, FRN, GPR, CGR, DET, DEX, LOP) | Small (FOS, DET, GPR, GRP, CGR, DET, FOS, LOP, BCL, DEX) | Small (FOS, DET, GPR) | Small (BLU, GPR, HCR) | Small (BLU, GPR, HCR) | Small (FOS, HCR, CGR, DET, DEX, GPR, LOP) | Small (FOS, DET, GPR, DET; FOS, LOP, BCL, DEX) |
| | **Long-Term (Permanent, Intermittent, or Recurring)** | | | | | | | |
| Magnitude | Negligible adverse | Minor adverse; minor beneficial | Minor beneficial and/or adverse | Major, adverse; minor beneficial | Major, adverse; minor beneficial | Major, adverse; minor beneficial | Minor beneficial and/or adverse | Minor beneficial and/or adverse |
| Extent | Large (basin-wide, FOS, DET, | Small, large | Small, large (basin-wide, | Small, large, (basin-wide, | Small, large, (basin-wide; | Small, large, (basin-wide; | Small, large (basin-wide, | Small, large (basin-wide, |

| Effect Factor | | Alternative | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NAA | 1 | 2A | 2B | 3A | 3B | 4 | 5 |
| | FCR, CGR, DEX, BCL, LOP, HCR, GPR) | (basin-wide; (FOS, DET, CGR, DEX, GPR, LOP, BLU, CTG, DOR, FCR, HCR) | FOS, DET, GPR, GRP, CGR, DET, FOS, LOP, BCL, DEX, BLU, FCR, HCR) | FOS, DET, GPR, BLU, FCR, CGR, LOP, HCR; CGR, BCL) | BLU, DET, FOS, GPR, HCR, LOP, CGR, FCR, BCL) | BLU, DET, FOS, GPR, HCR, LOP, CGR, FCR, BCL) | FOS, CGR, DET, DEX, GPR, LOP, BLU, CTG, DOR, FCR, HCR, BCL) | FOS, DET, GPR, BLU, FCR, HCR, LOP, CGR, BCL) |
| Duration Type | Recurring | Permanent or recurring | Recurring | Recurring | Recurring | Recurring | Permanent or recurring | Recurring |

In the following subsections, effects are discussed for the NAA, for each proposed measure that could have an impact, and for each of the action alternatives.

#### *3.19.5.3 Discussion of Effects by Measure(s)*

The measures which could impact drinking water and public health and safety are analyzed by measure(s) in this section. Measures that require additional tiered analysis, near-term operations measure, and measures proposed under the action alternatives are analyzed. It should be noted that for each these measures, water treatment at the drinking water facility would mitigate some of the effects of low-quality water. Without treatment, water quality effects would be a higher magnitude, duration or extent.

Site-specific project details for each construction measure will be determined during the preconstruction engineering and design phase. While general, qualitative effects from construction are discussed below on a programmatic level, the more detailed, site-specific analysis will be included in a tiered EA or EIS.

##### *3.19.5.3.1 Construction and/or Modification of Structural Measures*

Construction requires the use of large equipment which could lead to erosion and sedimentation from exposed soils and cause sediment to discharge into the reservoirs in the short- or medium-term. Discharges associated with construction activities would affect drinking water quality and could affect public health and safety as sediment laden runoff could pollute reservoir waters locally. However, construction activities would be required to meet NPDES permit requirements for stormwater discharges and such adverse effects would be negligible overall as measures to prevent erosion and sedimentation would be implemented during construction.

This section discusses the potential impacts to public health and safety and drinking water from the construction and/or modification of the structural measures shown below.

- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)
- Maintenance of existing and new fish release sites above dams (#726)
- Foster fish ladder temperature improvement
- Construct water temperature control tower (#105)
- Structural improvements to reduce TDG (#174)
- Restore upstream and downstream passage at drop structures (#639)
- Construct AFF (#722)
- Provide Pacific lamprey passage and infrastructure (#52)
- Construct structural downstream fish passage (#392)

- Operation, Maintenance, Repair, Replacement and Rehabilitation

**Maintaining revetments using nature-based engineering or altering revetments for aquatic ecosystem restoration (#9); maintenance of existing and new fish release sites above dams (#726)**

Maintaining or altering revetments (#9) and maintenance of existing and new fish release sites (#726) would occur basin wide and would affect drinking water and public health and safety from the construction work associated with the maintenance. Sediment-laden discharges from construction activities could affect drinking water quality. However, construction activities would require measures to prevent erosion and sedimentation would be implemented during construction. The short-term effects would be negligible in magnitude as measures to prevent erosion and sedimentation would be implemented during construction. This would include the stabilization of exposed soils using measures such erosion control blankets on slopes, temporary sediment storage basins, and silt fencing (USACE 2011).

In the long term, this maintenance work would have no effects on the public health and safety of drinking water.

**Foster fish ladder temperature improvement (#479); Construct WTC towers (#105); Structural improvements to reduce total dissolved gas (#174)**

Construction activities associated with the Foster fish ladder temperature improvement (#479), construction of WTC towers (#105), and structural improvements to reduce TDG (#174) would have negligible, adverse effects in the medium term as measures to prevent erosion and sedimentation would be implemented during construction similar to the maintenance of revetments (#9) described above.

Foster fish ladder temperature improvement (#479) would provide enhanced temperature control and normative (i.e., the standards of temperature needed for fish passage) water temperatures downstream for fish passage during regular operations. A new Forebay Warm Water Supply would allow warmer surface from the Foster forebay to be released downstream, resulting in blending with cooler surface water. The release of warmer water at the surface would have beneficial effects on the water quality of the reservoir as it would allow mixing of the surface waters. Inadequate mixing and lack of rainfall during summer months can lead to stagnant waters and stratification of the reservoir (i.e., the formation of thermal layers). Temporal stratification has adverse effects on water quality, including the entrainment of nutrients in the water column which can lead to eutrophication (see Section 3.19.1 Affected Environment where eutrophication is discussed). Therefore, the enhanced temperature controls that reduce stratification would have a beneficial minor effect on drinking water, and public health and safety. The effects would be long term recurring during reservoir releases.

Construction of WTC towers (#105) would have beneficial effects on water quality within the reservoir and adverse effects downstream. Cooler water is released from the bottom of the reservoir to provide more normative temperatures downstream. Release of middle to lower portions of the reservoir bottom can have high concentrations of nutrients and metals from the sediment accumulated in the bottom of the reservoir (Kennedy & Gaugush 1988). The downstream waters used for drinking water would be adversely affected by deep reservoir releases due to the influx of concentrated nutrients. The effects would be adverse and beneficial minor, long term and recurring when reservoir releases occur.

Structural improvements to reduce TDG (#174) would have beneficial effects on drinking water and public health and safety in the long term. The reduction in TDG would improve water quality for drinking water as it would reduce the amount of nitrogen in downstream waters. The effects would be minor as the amount of nitrogen could be detected by monitoring. The effects would be long term and permanent in duration.

**Restore upstream and downstream passage at drop structures (#639), construct AFF (#722), provide Pacific lamprey passage and infrastructure (#52), construct structural downstream fish passage infrastructure (#392)**

These four fish infrastructure measures would have similar effects. The construction effects would be adverse and negligible as measures to prevent erosion and sedimentation would be implemented. The effects of restoring upstream and downstream passage at drop structures (#639) would be short term in duration. For the construction of AFFs (#722), providing Pacific lamprey passage and infrastructure (#52), and constructing structural downstream fish passage infrastructure (#392), construction effects would be medium term in duration.

In the long term, there would be no effects to public health and safety – drinking water associated with fish collection and fish passage infrastructure.

**Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRRR)**

Scheduled/routine maintenance and non-routine maintenance activities would be adverse as effects of sediment-laden discharges from construction activities could affect drinking water quality. Effects would be negligible in magnitude as measures to prevent erosion and sedimentation would be implemented during construction. Therefore, effects are adverse and negligible in the short term. Similarly, effects of major maintenance and repairs would be adverse and negligible however the duration of major maintenance is medium and long term recurring.

#### *3.19.5.3.2 Implementation of Water Management Measures*

This section discusses the potential impacts to public health and safety and drinking water from the implementation of the following water management measures:

- Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166)
- Use spillway for summer surface spill (#721)

- Pass water over spillway in spring for fish passage (#714)
- Deeper fall reservoir drawdowns for fish passage (#40)
- Spring reservoir drawdown for downstream fish passage (#720)
- Fall Creek Drawdown
- Augment instream flows by using the inactive pool (#718)
- Augment instream flows by using the power pool (#304)
- Reduce minimum flows to Congressionally authorized minimum flow requirements (#723)
- Integrated temperature and habitat flow regime (#30a)
- Refined integrated temperature and habitat flow regime (#30b)
- Near-term Operations Measure

**Use regulating outlets (ROs) to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166)**

Using ROs to discharge cold water (#166) would have adverse effects on downstream water quality. Discharging cold water would allow the reservoir to 'turnover' as described in Section 2.2.2.2 Water Quality Measures. However, the discharge from the ROs of the reservoir would release concentrated nutrients upward due to mixing in the water column from the lower depths of the reservoir where sediment and heavy metals accumulate in low oxygen conditions. The decreased quality of water would also be released downstream from where drinking water is sourced. The effects would be adverse and minor, short and long term recurring during reservoir releases.

**Use spillway for summer surface spill (#721); Pass water over spillway in spring for fish passage (#714)**

Using the spillway for summer surface spill (#721) would have beneficial and adverse minor effects to drinking water and public health and safety as it would promote mixing of the reservoirs' surface waters which could reduce stratification locally as described previously under Section 3.19.6.3.1 under the Foster fish ladder temperature improvement (#479). Conversely, when water flows over the spillway air dissolves into the water which causes nitrogen to increase dramatically (EPA, 1971). Increased nitrogen can be conducive to algal growth formation which could cause water quality to decline. Excess nitrogen is also harmful if ingested. The release of warmer water at the surface would be beneficial and minor, short and long term recurring during summer spillway releases.

Spring spillway fish passage (#714) would have the same effects as use of the spillway for summer surface spill (#721). The release of water from the surface spillway would have beneficial and adverse minor, short and long term recurring during spillway releases.

**Augment instream flows by using the inactive pool (#718); Augment instream flows by using the power pool (#304); Reduce minimum flows to Congressionally authorized minimum flow requirements (#723)**

Augmenting instream flows by using the inactive pool (#718) would have adverse effects on drinking water and public health and safety. It would have minor, small, and long-term recurring effects on the availability of drinking water as the inactive pool is used only for emergencies or when the conservation pool has been emptied. This measure would have adverse effects on drinking water quality and public health and safety as well since water from the deepest layer of the reservoir would be released (see Figure 2 Reservoir storage layers in the Glossary). See the discussion under 3.19.6.3.1, construction of WTC towers (#105). The effects would be minor, short- and long-term recurring when reservoir releases occur.

Augment instream flows by using the power pool (#304) would have adverse effects on drinking water and public health and safety. Power pool storage used for hydropower generation would be separately allocated from conservation storage used for drinking water. Therefore, it would have negligible, short- and long-term recurring effects on the availability of drinking water. However, effects would also be minor because water quality would be reduced due to the release of highly concentrated nutrients from the middle of the reservoir – similar to the effects use of the inactive pool.

Reducing minimum flows to Congressionally authorized minimum flows (#723) would have beneficial effects for drinking water and public health and safety as it would allow capture of spring runoff for conservation, thereby increasing water availability. The effects on water availability are minor, short and long-term recurring when flows are reduced in the spring. Reducing minimum flows to the Congressionally authorized minimum flows requirements would allow reservoirs to capture more spring runoff rather than releasing it. These minimum flows would also maintain water quality standards. Therefore, effects would be beneficial minor, short and long term permanent when flows are reduced.

**Integrated temperature and habitat flow regime (#30a); Refined integrated temperature and habitat flow regime (#30b)**

Integrated temperature and habitat flow regime (#30a) would have beneficial effects on drinking water and public health and safety. The adaptive fish flows would prevent stagnancy of the water, thereby maintaining water quality. Operation of the WVS follows a four-season cycle, winter flood risk management (FRM) season and summer conservation season with spring refill and fall release periods as discussed in Section 1.10. Therefore the effects would be beneficial minor, short and long term recurring.

The refined integrated temperature and habitat flow regime (#30b) would have similar beneficial effects on drinking water and public health and safety as the integrated temperature and habitat flow regime (#30a). The adaptive fish flows would prevent stagnancy of the water, thereby maintaining water quality. The effects would be beneficial minor, short and long term recurring.

**Deeper fall reservoir drawdowns for fish passage (#40); Spring reservoir drawdown for downstream fish passage (#720); Fall Creek drawdown**

The reservoir drawdowns would have adverse effects on water quality downstream. Nutrients at the bottom of the reservoir flow would be released downstream, reducing water quality and would have effects similar to the effects described under Section 3.19.6.3.1 for construction of WTC towers (#105). The WTC towers would release water from the lower depths of the reservoir similar to drawdown operations where the accumulated sediment would be released. The effects would be adverse minor, and short and long term recurring in the fall and spring.

The spring and fall drawdowns result in elevations below the minimum conservation elevation and therefore do not maintain M&I water supply storage. The spring drawdown would have a major effect on conservation pool storage because the spring drawdowns can affect the ability to refill system-wide storage. Conversely, the fall drawdowns only have a negligible to minor effect because stored water usage during this period is minimal. The effects of the drawdowns on water availability would be long term recurring when drawdowns would occur in the fall and spring.

**Near-term Operations Measure**

The Near-term Operations Measure are a suite of 16 operations described in Chapter 2. The operations measures are analyzed by grouping measures below by where water is released from the dam, either through the regulating outlets or surface spillway releases. The depth in the reservoir from where water is released would have different effects on water quality. Water released from the surface spillway would have less adverse and more beneficial effects than water released from the lower depths of the reservoir such as from the regulating outlets which is explained below.

***RO Release***

- Nighttime RO prioritization for improved downstream fish passage at Detroit Dam;
- Deep drawdown and RO prioritization for improved downstream fish passage at Cougar Dam;
- Delayed reservoir refill and RO prioritization for improved downstream fish passage at Cougar Dam;
- Nighttime RO prioritization for improved downstream fish passage (downstream fish passage) at Hills Creek Dam;
- Deep drawdown and RO prioritization for improved downstream fish passage at Lookout Point Dam;
- Extended deep drawdown and RO prioritization for improved downstream fish passage at Falls Creek Dam and delayed reservoir refill and RO prioritization for improved downstream fish passage at Falls Creek Dam

Using ROs to discharge cold water would have adverse effects on downstream waters, reducing water quality where drinking water is sourced. Discharging cold water would allow the reservoir to ‘turnover’ as described in Section 2.2.2.2. However, the discharge from the ROs of the reservoir would also release concentrated nutrients upward due to mixing in the water column from the lower depths of the reservoir where sediment and heavy metals accumulate in low oxygen conditions. The decreased quality of water would also be released downstream. Therefore, effects would be adverse and minor as changes to water quality would be small and within regulatory standards for water quality conditions for drinking water. The effects would be large in extent affecting the reservoir and downstream waters and short and long term recurring during reservoir releases. The deep drawdown, extended deep drawdown, and delayed reservoir refill and RO prioritization and would have adverse, negligible to minor, short and long-term recurring effects as the drawdown occurs in the fall and winter when stored water usage is minimal. The effects on water quality would be adverse minor, large, short and long term recurring in the fall and spring. These effects are similar to the effects of the reservoir drawdowns analyzed in the previous section above.

***Spillway release***

- Spread spill across spillways to reduce downstream TDG exceedances at Big Cliff Dam;
- Utilize spillway for improved downstream fish passage in the spring; perform spill operation until 01 May or for 30 days, whichever is longer at Green Peter Dam;
- Delay refill and utilize spillway in the spring for improved downstream fish passage; use the fish weir in the summer for improved downstream temperature management and upstream fish migration/passage at Green Peter Dam;
- Utilize the spillway for improved downstream fish passage in the fall at Foster Dam

Using the spillway for the near-term operations measure would have beneficial effects to drinking water and public health and safety as it would promote mixing of the reservoirs’ surface waters which could reduce stratification locally as described for the Foster fish ladder temperature improvement (#479) in Section 3.19.6.3.1. The release of the warmer water at the surface of the reservoir would also have beneficial and minor, short- and long-term recurring effects during summer spillway releases. Conversely, when water flows over the spillway air dissolves into the water which causes nitrogen to increase dramatically which has adverse effects to drinking water quality. Therefore effects would be beneficial and adverse, minor, short and long term recurring.

***Combined RO and Spillway release***

- Spring downstream fish passage and operational downstream temperature management at Detroit dam
- Utilize spillway for improved downstream fish passage in the spring at Lookout Point Dam; RO use in the fall for downstream temperature management at Lookout Point Dam

These measures use a combination of using both the RO and the spillway which would result in adverse and beneficial, minor, and long term recurring effects similar to the effects analyzed under the RO release and Spillway release measures above. The effects would be beneficial and adverse minor, short and long term recurring.

#### *3.19.5.4 No Action Alternative*

This analysis addresses the effects if the existing O&M of the WVS system would continue. The current operations which could have either beneficial or adverse effects on the drinking water and public health and safety. Water treatment would also minimize or eliminate the reduced quality of the drinking water. Effects of temperature control and TDG reduction measures would be beneficial and adverse minor, large, short and long term recurring. The effects of augmenting flows would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large short- and long-term recurring effects on drinking water quality. Passing water over the spillway has beneficial and adverse, minor, large, short- and long- term recurring effects. For the existing operations continued forward, the effects would be adverse, minor, large, short and long term recurring due to the Fall Creek drawdown; adverse, negligible, small, and short term recurring for routine maintenance; and adverse negligible, small, and medium- and long-term recurring effects for major maintenance.

The NAA includes water quality, flow, and upstream and downstream passage operations. Water quality operations include using the spillway to release warm surface water and manage downstream temperatures at Foster and Detroit; strategically using outlets to meet temperature targets (when possible) at Fall Creek; operating the Cougar WTC tower to manage downstream temperatures; spreading spill across the Dexter and Big Cliff spillways to reduce TDG; and discharging water through the powerhouse at power-producing dams to reduce TDG.

These water quality operations to control temperature and reduce TDG would continue to be beneficial and adverse for drinking water. The release of warmer water at the surface would have beneficial effects on the water quality of the reservoir as it would allow mixing of the surface waters and would reduce stratification of the reservoir as discussed under the Foster fish ladder temperature improvement in Section 3.19.6.3.1. Conversely, when water flows over the spillway air dissolves into the water which causes nitrogen to increase dramatically (EPA, 1971). Increased nitrogen can be conducive to algal growth formation which could cause water quality to decline. Excess nitrogen is also harmful if ingested. Therefore, effects of temperature control and TDG reduction measures would be beneficial and adverse minor, large, short and long term recurring.

Flow operations include meeting the 2008 BiOp targets basin-wide and augmenting flows using the inactive or power pool at Green Peter. Maintaining operational flow targets for fish and wildlife conservation would be adverse and negligible in the short term, medium term, and long term on the availability of water for drinking water as it would be separately allocated for municipal and industrial (M&I) water supply. The effects would be large as conservation releases would affect the entire reservoir and downstream receiving water bodies. As discussed above in Sections 3.19.6.3.2, augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large short- and long-term recurring effects on drinking water quality.

Fish passage operations include passing fish over the Foster spillway and through the lowest RO at Fall Creek (Fall Creek drawdown). Passing water over the spillway has beneficial and adverse, minor, large, short- and long- term recurring effects. The Fall Creek drawdown is discussed below under existing operations continued forward.

#### *5.19.5.4.1 Existing operations continued forward*

**Fall Creek Drawdown**

Reservoir releases or drawdowns would cause concentrated nutrients, heavy metals and sediment to be released downstream, reducing the quality of the drinking water resource. Therefore, effects would be adverse minor, large in extent affecting the entire reservoir and downstream receiving waters, short and long term recurring throughout the year as the pool volumes are adjusted. Effects on water availability would be negligible as the Fall Creek drawdown occurs in November when stored water usage during this period is minimal. Therefore, effects on water availability would be adverse negligible, large, short and long term recurring.

**Continued Operation of Existing Adult Fish Facilities**

O&M activities associated with existing AFFs would continue to have adverse negligible effects on public health and safety – drinking water. Water used for flushing of fish facilities or effluent water may be high in pollutants. However, hatcheries are required to meet water quality standards for their waste/effluent water (EPA 2021j). These discharges from fish facilities must be within the limits set forth in NPDES permit requirements. Thresholds are set for total suspended solids (TSS), settleable solids, temperature, and pH and must not be exceeded during routine monitoring. Thus, any effects would be adverse negligible, small in extent localized to the area of discharge, short and long term recurring during the regular flushing of facilities during maintenance.

**Operation, Maintenance, Repair, Replacement and Rehabilitation**

Scheduled/routine maintenance and non-routine maintenance activities would be adverse as effects of sediment-laden discharges from construction activities could affect drinking water quality. Effects would be negligible in magnitude as measures to prevent erosion and sedimentation would be implemented during construction. Therefore, effects are adverse and negligible in the short term. Similarly, effects of major maintenance and repairs would be adverse and negligible however the duration of major maintenance is medium- and long term recurring.

#### *5.19.5.4.2 Climate Change*

The impact on public health and safety – drinking water due to environmental conditions which may change as a result of climate change is analyzed in this section. The climate change projected trend information is based on the hydrologic trends discussed in Appendix F.

Increased extreme precipitation events can cause stream flows to increase rapidly leading to increased potential for sedimentation and erosion. This can diminish the quality of water entering the reservoirs due to the sedimentation and influx of nutrients and contaminants from the watershed. These impacts would be minor, large in extent affecting the entire reservoir and downstream receiving waters, and long-term intermittent and/or permanent as extreme precipitation events occur.

Prolonged periods between rainfall events (or drought periods) could cause decreases in streamflow, leading to less water availability and the ability of the WVS to provide conservation storage and storage for M&I. Increased temperatures due to climate change could also lead to higher evapotranspiration rates thereby reducing the amount of water available for drinking water. Decreased streamflow and increasing temperatures would be adverse and have a moderate effect as the availability of drinking water could be affected. The effects would be large in extent affecting the drinking water available to users basin-wide, and long term intermittent as drought periods occur over the period of the analysis.

Warmer temperatures from climate change could also provide favorable conditions for the propagation of harmful algal blooms (HABs), which can discolor, cloud, or cover the water's surface and affect drinking water. Wildfire ash can land in reservoirs, streams, and rivers, increasing turbidity and adversely affecting the water quality of those water bodies which communities rely on for drinking water.

#### *5.19.5.4.3 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Under Alternative 1, fish passage would be improved through storage-focused measures by maximizing refill volumes of conservation pools and tapping into the power pool, augmenting flow to the congressionally authorized minimum flows. This would increase the likelihood of refilling to the maximum conservation pool levels.

Effects are the similar to the effects described under the Discussion of Effects by Measure(s). Alternative 1 effects would be adverse negligible, small, and short term or medium term for the construction and/or modification of any structural measures which include maintenance or alteration of revetments (#9); the maintenance of existing and new fish release sites (#726); Foster fish ladder temperature improvement (#479); construction of WTC towers (#105); restoring upstream and downstream passage at drop structures (#639); construction of AFFs (#722); providing Pacific lamprey passage and infrastructure (#52); and construction structural fish passage infrastructure (#392). In the long term, there would be no effects to public health and safety associated with fish collection, fish passage infrastructure and AFFs.

Maintenance or alteration of revetments (#9); the maintenance of existing and new fish release sites (#726); restoring upstream and downstream passage at drop structures (#639); construction of AFFs (#722); providing Pacific lamprey passage and infrastructure (#52); and construction structural fish passage infrastructure (#392) have no long-term effects. Foster fish ladder temperature improvement (#479) and construction of WTC towers (#105) would have beneficial, minor, small and long-term recurring effects.

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse negligible, small, and long-term recurring effects on water availability, and adverse minor, large and long-term recurring effects on water quality. Reducing minimum flows to Congressionally authorized minimum flow requirements (#723) basin-wide would have beneficial minor, large and long-term recurring effects when flows are reduced in the spring on water availability. Effects on water quality would be also beneficial minor, large, and long term and recurring. Structural improvements to reduce total dissolved gas (#174) would have adverse minor, large effects in the short and long term permanent in duration.

It should be noted that for each these measures, water treatment at the drinking water facility would mitigate some of the effects of low-quality water. Without treatment, water quality effects would be a higher magnitude, duration or extent.

##### *3.19.5.4.4 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) basin-wide; maintenance of existing and new fish release sites above dams (#726); Operation, maintenance, repair, replacement and rehabilitation*

Maintenance and alteration of revetments (#9) and the maintenance of existing and new fish release sites (#726) would occur basin-wide. The effects would be adverse and negligible in magnitude as measures to prevent erosion and sedimentation would be implemented during construction. Effects would be and small near the vicinity of the maintenance activities at the revetments and short term during construction. In the long term, the revetments would have no effects on drinking water and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects.

Construction effects of these measures would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.19.5.4.5 Foster Fish Ladder Temperature Improvement (#479); Construct WTC Towers (#105) at Detroit, Green Peter and Lookout Point dams; Structural improvements to reduce total dissolved gas (#174) at Cougar, Detroit, Dexter, Foster, Green Peter, and Lookout Point dams*

Foster fish ladder temperature improvement (#479) would have beneficial effects. Construction of a new Forebay Warm Water Supply pipe would allow warmer surface from the Foster forebay to be released downstream, resulting in blending with cooler surface water. The effects would be beneficial, minor, large affecting the entire reservoir and downstream receiving waters, and long term recurring during reservoir releases.

Construction of WTC towers (#105) would have beneficial and adverse effects on water quality. The effects would be minor, large affecting the reservoir and downstream reaches, and long term and recurring when reservoir releases occur.

Structural improvements to reduce total dissolved gas (#174) would have adverse and minor, and large effects affecting the entire reservoir and the downstream receiving waters. The effects would be long term and permanent in duration.

Construction effects of these measures would be adverse negligible, small in the medium term as measures to prevent erosion and sedimentation would be implemented during construction.

###### *3.19.5.4.6 Augment instream flows by using the inactive pool (#718) at Blue River, Cottage Grove, Dorena, and Falls Creek dams; Augment instream flows by using the power pool (#304) Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point dams; Reduce minimum flows to Congressionally authorized minimum flow requirements (#723) basin-wide; Fall Creek drawdown*

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large short- and long-term recurring effects on water quality.

Reducing minimum flows to Congressionally authorized minimum flow requirements (#723) would be beneficial effects on water quality and public health and safety as it would allow capture of spring runoff for conservation thereby increasing water availability. The effects on water availability are beneficial minor, large, short and long term recurring when flows are reduced in the spring. These minimum flows would also maintain water quality standards. Effects on water quality would be also beneficial minor, large, and long term and permanent.

Effects of the Fall Creek drawdown would be adverse minor, large, short and long term recurring.

###### *3.19.5.4.7 Restore upstream and downstream passage at drop structures at Fern Ridge Dam (#639); construct AFFs at Green Peter Dam (#722); provide Pacific lamprey passage and infrastructure at Fern Ridge and Green Peter dams (#52); and construct structural fish passage infrastructure (#392) at Detroit, Foster, Green Peter, Lookout Point, Big Cliff, and Dexter dams; continued operation of existing adult fish facilities*

The construction effects of restoring upstream and downstream passage at drop structures (#639) would be negligible, small, in the short term. For the construction of AFFs (#722), providing Pacific lamprey passage and infrastructure (#52), and constructing structural downstream fish passage infrastructure (#392), construction effects would be negligible, small, in the medium term. In the long term, there would be no effects to public health and safety associated with fish collection, fish passage infrastructure and AFFs.

The continued operation of existing adult fish facilities would be adverse, negligible, small, short and long term recurring during the regular flushing of facilities during maintenance.

##### *3.19.5.4.8 Climate Change*

Alternative 1 would combine storage-focused measures in order to improve fish passage. The measures in Alternative 1 would improve reservoir storage and improve water quality by reducing TDG and normalizing temperatures. Therefore, the effects of climate change on drinking water would be less severe under Alternative 1 than any other alternative, including the NAA. Climate change in combination with the measures under Alternative 1 would have adverse, minor, large, long-term intermittent and /or permanent effects to drinking water.

#### ***3.19.5.5 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative***

Under Alternative 2A, integrated temperature and habitat flow regimes would be utilized as well as using the power pool to augment flows. Structural and operational measures are proposed to address water quality as well as the Near-Term Operations Measure(s) as discussed under Section 2.2.5. The effects of the measures proposed under Alternative 2A are analyzed in this section. Effects are the similar to the effects described under the Discussion of Effects by Measure(s).

Effects would be adverse negligible, small, and short term or medium term for the construction and/or modification of any structural measures which include maintenance or alteration of revetments (#9); the maintenance of existing and new fish release sites (#726); Foster fish ladder temperature improvement (#479); construction of WTC towers (#105); construction of AFFs (#722); providing Pacific lamprey passage and infrastructure (#52); and construction structural fish passage infrastructure (#392). Maintenance or alteration of revetments (#9); the maintenance of existing and new fish release sites (#726); construction of AFFs (#722); providing Pacific lamprey passage and infrastructure (#52); and construction structural fish passage infrastructure (#392) have no long-term effects. Foster fish ladder temperature improvement (#479) would have beneficial, minor and long-term recurring effects.

The effects of using ROs to discharge cold water (#166) would be adverse minor, large, short and long term recurring on water quality. The deeper fall reservoir drawdowns for fish passage (#40) would have adverse, minor, large, short- and long-term recurring effects on water quality downstream and adverse, negligible to minor, large, short- and long-term recurring effects on water availability. Using the spillway for summer surface spill (#721) and passing water over spillway in spring for fish passage (#714) would have beneficial and adverse minor, large, short- and long-term recurring effects. Construction effects the deeper fall reservoir drawdowns for fish passage (#40) and using the spillway for summer surface spill (#721) would also be adverse and negligible in the short or medium term as measures to prevent erosion and sedimentation would be implemented during construction.

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large and long-term recurring effects on water quality. The integrated temperature and habitat flow regime (#30a) would have beneficial minor, small, short- and long-term effects.

The Near-term Operations Measure would result in adverse minor, large, short- and long-term recurring effects; and beneficial negligible to minor, large, short- and long-term recurring effects.

It should be noted that for each these measures, water treatment at the drinking water facility would mitigate some of the effects of low-quality water. Without treatment, water quality effects would be a higher magnitude, duration or extent.

###### *3.19.5.5.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) basin-wide; maintenance of existing and new fish release sites above dams (#726) basin-wide; Operation, maintenance, repair, replacement and rehabilitation*

Maintenance and alteration of revetments (#9) and the maintenance of existing and new fish release sites (#726) would occur basin-wide. The effects would be adverse and negligible in magnitude as measures to prevent erosion and sedimentation would be implemented during construction. Effects would be small near the vicinity of the maintenance activities at the revetments and short term during construction. In the long term, the revetments would have no effects on drinking water and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse small, negligible, and long-term recurring effects.

Construction effects of these measures would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

###### *3.19.5.5.2 Foster Fish Ladder Temperature Improvement (#479); Construct WTC tower (#105)*

Foster fish ladder temperature improvement (#479) would have beneficial effects. Construction of a new Forebay Warm Water Supply pipe would allow warmer surface from the Foster forebay to be released downstream, resulting in blending with cooler surface water. The effects would be beneficial, minor, large affecting the entire reservoir and downstream receiving waters, and long term and recurring during reservoir releases.

The construction of WTC towers (#105) would have beneficial and adverse effects on water quality. The effects would be minor, large affecting the reservoir and downstream reaches, and long term and recurring when reservoir releases occur.

Construction effects of these measures would be adverse negligible, small in the medium term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.19.5.5.3 Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) at Green Peter Dam; Deeper fall reservoir drawdowns for fish passage (#40) at Green Peter Dam; Fall Creek drawdown*

Using ROs to discharge cold water (#166) would have adverse effects on downstream water quality. The effects would be adverse and minor, large, short and long term recurring during reservoir releases.

The deep reservoir drawdowns would have adverse effects on water quality downstream. The effects would be adverse minor, large, and short and long term recurring in the fall.

The deeper fall reservoir drawdown for fish passage (#40) results in elevations below the minimum conservation elevation and therefore do not maintain M&I water supply storage. The fall drawdowns would have a negligible to minor effect because stored water usage during this period is minimal. The effects of the fall drawdowns on water availability would be large, short and long term recurring in the fall.

Construction effects of deeper fall reservoir drawdown for fish passage (#40) would be adverse negligible, small in the short or medium term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.19.5.5.4 Use spillway for surface spill in summer (#721) at Green Peter Dam; Pass water over spillway in spring for fish passage (#714) at Green Peter Dam*

Using the spillway for summer surface spill (#721) and passing water over spillway in spring for fish passage (#714) would have beneficial and adverse minor effects to drinking water and public health and safety. The effects would be large affecting the entire reservoir and downstream receiving waters, and short and long term and recurring during summer and spring spillway releases.

Construction effects of using the spillway for summer surface spill (#721) would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.19.5.5.5 Augment instream flows by using the inactive pool (#718) at Blue River and Falls Creek dams; Augment instream flows by using the power pool (#304) at Cougar, Detroit, Green Peter, Hills Creek, and Lookout Point dams*

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large, short- and long-term recurring effects on water quality.

##### *3.19.5.5.6 Integrated temperature and habitat flow regime (#30a) basin-wide*

Integrated temperature and habitat flow regime (#30a) would have beneficial effects on drinking water and public health and safety. The effects would be minor, small, short and long term.

##### *3.19.5.5.7 Construct adult fish facilities at Green Peter Dam (#722); Pacific lamprey passage and infrastructure at Green Peter Dam (#52); construct structural downstream fish passage (#392) at Cougar, Detroit, Foster, Lookout Point, Big Cliff, and Dexter dams; Continued operation of existing adult fish facilities*

The construction effects of the construction of AFFs (#722), providing Pacific lamprey passage and infrastructure (#52), and constructing structural downstream fish passage infrastructure (#392), would be adverse, negligible, small, short or medium term in duration. In the long term, there would be no effects to public health and safety associated with fish collection and fish passage infrastructure.

The continued operation of existing adult fish facilities would be adverse, negligible, small, short and long term recurring during the regular flushing of facilities during maintenance.

##### *3.19.5.5.8 Near-term Operations Measure*

The Near-term Operations Measure are a suite of operations measures in which the impacts were analyzed by grouping measures which include drawdowns utilizing the ROs and/or releasing water via the spillway. These measures would result in adverse minor, large, short- and long-term recurring effects; and beneficial negligible to minor, large, short- and long-term recurring effects.

##### *3.19.5.5.9 Climate Change*

Alternative 2A would integrate water management flexibility and ESA-listed fish measures (using structural downstream passage at Cougar Dam). The measures in Alternative 2A would improve water quality by reducing TDG and normalizing temperatures. It would also provide fish passage. However, it would not improve reservoir storage like Alternative 1. In general, climate change would exacerbate effects from deep drawdowns: as temperatures increase and snowpacks decline, reservoirs may struggle to reach their conservation pool elevations over time, which would directly affect drinking water. Climate change in combination with the measures under Alternative 2A would have adverse, minor, large, long-term intermittent and /or permanent effects on drinking water.

### *3.19.5.6 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Under Alternative 2B, the effects to public health and safety – drinking would be the same as those described under Alternative 2A. The difference is that the downstream passage measure at Cougar Dam is changed from a structural fish passage structure under 2A to changing of operations to a deep fall and spring drawdown with the construction of a diversion tunnel under 2B. The Near-Term Operations Measure(s) are also proposed under this alternative.

The effects of the measures proposed under Alternative 2B are analyzed in this section. Effects are the similar to the effects described under the Discussion of Effects by Measure(s). Effects would be adverse negligible, small, and short term or medium term for the construction and/or modification of any structural measures which include maintenance or alteration of revetments (#9); the maintenance of existing and new fish release sites (#726); Foster fish ladder temperature improvement (#479); construction of WTC towers (#105); construction of AFFs (#722); providing Pacific lamprey passage and infrastructure (#52); and construction structural fish passage infrastructure (#392). Maintenance or alteration of revetments (#9); the maintenance of existing and new fish release sites (#726); construction of AFFs (#722); providing Pacific lamprey passage and infrastructure (#52); and construction structural fish passage infrastructure (#392) have no long-term effects. Foster fish ladder temperature improvement (#479) and construction of WTC towers (#105) would have beneficial, minor and long-term recurring effects.

The effects of using ROs to discharge cold water (#166) would be adverse minor, large, short and long term recurring on water quality. The deeper fall reservoir drawdowns for fish passage (#40) would have adverse, minor, large, short- and long-term recurring effects on water quality downstream and adverse, negligible to minor, large, short- and long-term recurring effects on water availability. Using the spillway for summer surface spill (#721) and passing water over spillway in spring for fish passage (#714) would have beneficial and adverse minor, large, short- and long-term recurring effects. Construction effects the deeper fall reservoir drawdowns for fish passage (#40) and using the spillway for summer surface spill (#721) would also be adverse and negligible in the short or medium term as measures to prevent erosion and sedimentation would be implemented during construction.

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large and long-term recurring effects on water quality. The integrated temperature and habitat flow regime (#30a) would have beneficial minor, small, short- and long-term effects.

The Near-term Operations Measure would result in adverse minor, large, short- and long-term recurring effects; and beneficial negligible to minor, large, short- and long-term recurring effects.

It should be noted that for each these measures, water treatment at the drinking water facility would mitigate some of the effects of low-quality water. Without treatment, water quality effects would be a higher magnitude, duration or extent.

##### *3.19.5.6.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) basin-wide; maintenance of existing and new fish release sites above dams (#726) basin-wide; Operation, maintenance, repair, replacement and rehabilitation*

Maintenance and alteration of revetments (#9) and the maintenance of existing and new fish release sites (#726) would occur basin-wide. The effects would be adverse and negligible in magnitude as measures to prevent erosion and sedimentation would be implemented during construction. Effects would be small near the vicinity of the maintenance activities at the revetments and short term during construction. In the long term, the revetments would have no effects on drinking water and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects.

Construction effects of these measures would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.19.5.6.2 Foster Fish Ladder Temperature Improvement (#479); Construct WTC tower (#105) at Detroit Dam*

Foster fish ladder temperature improvement (#479) would have beneficial effects. Construction of a new Forebay Warm Water Supply pipe would allow warmer surface from the Foster forebay to be released downstream, resulting in blending with cooler surface water. The effects would be beneficial, minor, large affecting the entire reservoir and downstream receiving waters, and long term and recurring during reservoir releases.

The construction of WTC towers (#105) would have beneficial and adverse effects on water quality. The effects would be minor, large affecting the reservoir and downstream reaches, and long term and recurring when reservoir releases occur.

Construction effects of these measures would be adverse negligible, small in the medium term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.19.5.6.3 Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) at Green Peter Dam; Deeper fall reservoir drawdowns for fish passage (#40) at Cougar and Green Peter dams; spring reservoir drawdown for downstream fish passage (#720) at Cougar Dam; Fall Creek drawdown*

Using Ros to discharge cold water (#166) would have adverse effects on downstream water quality. The effects would be adverse minor, large, short and long term recurring during reservoir releases.

The reservoir drawdowns would have adverse effects on water quality downstream. The effects are minor, large, short and long term recurring in the fall or spring.

The spring reservoir drawdown for downstream fish passage (#720) would have a major, large, and short- and long-term effects on water availability. The deeper fall reservoir drawdowns for fish passage (#40) would have a negligible to minor, large, short- and long-term recurring effects.

Effects of the Fall Creek drawdown on drinking water quality and water availability would be adverse minor, large, short and long term recurring.

Construction effects of the spring reservoir drawdown for downstream fish passage (#720) and deeper fall reservoir drawdown for fish passage (#40) would be adverse, negligible, small in the short or medium term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.19.5.6.4 Use spillway for surface spill in summer (#721) at Green Peter Dam; Pass water over spillway in spring for fish passage (#714) at Green Peter Dam*

Using the spillway for summer surface spill (#721) and passing water over spillway in spring for fish passage (#714) would have beneficial and adverse minor effects to drinking water and public health and safety. The effects would be large affecting the entire reservoir and downstream receiving waters, short and long term recurring during summer and spring spillway releases.

Construction effects of using the spillway for summer surface spill (#721) would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

##### *3.19.5.6.5 Augment instream flows by using the inactive pool (#718) at Blue River and Falls Creek dams; Augment instream flows by using the power pool (#304) at Detroit, Green Peter, Hills Creek, and Lookout Point dams*

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large, short- and long-term recurring effects on water quality.

###### *3.19.5.6.6 Integrated temperature and habitat flow regime (#30a) basin-wide*

Integrated temperature and habitat flow regime (#30a) would have beneficial effects on drinking water and public health and safety. The effects would be minor, small, short and long term.

###### *3.19.5.6.7 Construct adult fish facilities at Green Peter Dam (#722); Pacific lamprey passage and infrastructure at Green Peter Dam (#52); construct structural downstream fish passage (#392) at Detroit, Foster, Lookout Point, Big Cliff, and Dexter dams; continued operation of existing adult fish facilities*

The construction effects of the construction of AFFs (#722), providing Pacific lamprey passage and infrastructure (#52), and constructing structural downstream fish passage infrastructure (#392), would be adverse, negligible, small, short or medium term in duration. In the long term, there would be no effects to public health and safety associated with fish collection and fish passage infrastructure.

The continued operation of existing adult fish facilities would be adverse, negligible, small, short and long term recurring during the regular flushing of facilities during maintenance.

###### *3.19.5.6.8 Near-term Operations Measures*

The Near-term Operations Measures are a suite of operations measures in which the impacts The Near-term Operations Measures are a suite of operations measures in which the impacts were analyzed by grouping measures which include drawdowns utilizing the ROs and/or releasing water via the spillway. These measures would result in adverse minor, large, short- and long-term recurring effects; and beneficial negligible to minor, large, short- and long-term recurring effects.

###### *3.19.5.6.9 Climate Change*

Alternative 2B would integrate water management flexibility and ESA-listed fish measures (using a deep drawdown to Cougar Dam's DT). Climate change is expected to adversely affect water quantity and air and water quality. The measures in Alternative 2B would improve water quality by reducing TDG and normalizing temperatures. It would also provide fish passage. However, it would not improve reservoir storage like Alternative 1. Due to one more deep drawdown than Alternative 2A, climate change would exacerbate the effects of Alternative 2B more than Alternatives 1 or 2A. However overall, the effects would be the same as under Alternative 2A; climate change in combination with the measures under Alternative 2B would have adverse, minor to moderate, large, long-term intermittent and/or permanent effects to drinking water.

### *3.19.5.7 Alternative 3A – Operations-Focused Fish Passage Alternative*

Under Alternative 3A, improved fish passage is proposed through the modifying of operations rather than focusing on storage (Alternative 1) or structural measures (Alternative 4). The Near-Term Operations Measure(s) are also proposed under this alternative.

Effects under Alternative 3A are the similar to the effects described under the Discussion of Effects by Measure(s). Alternative 3A effects would be similar to Alternatives 2B due to the spring drawdown. Effects would be adverse negligible, small, and short term or medium term for the construction and/or modification of any structural measures which include maintenance or alteration of revetments (#9); the maintenance of existing and new fish release sites (#726); construction of AFFs (#722); and providing Pacific lamprey passage and infrastructure (#52. Maintenance or alteration of revetments (#9); the maintenance of existing and new fish release sites (#726); construction of AFFs (#722) and providing Pacific lamprey passage and infrastructure (#52) have no long-term effects.

The effects of using ROs to discharge cold water (#166) would be adverse minor, large, short and long term recurring on water quality. Using the spillway for summer surface spill (#721) and passing water over spillway in spring for fish passage (#714) would have beneficial and adverse minor, large, short- and long-term recurring effects during summer and spring spillway releases. The reservoir drawdowns would have adverse, minor, large, short and long term recurring in the fall and spring. The spring reservoir drawdown for downstream fish passage (#720) would have a major, large, and short- and long-term effects on water availability. The deeper fall reservoir drawdowns for fish passage (#40) would have a negligible to minor, large, short- and long-term recurring effects. Construction effects the deeper fall reservoir drawdowns for fish passage (#40) and using the spillway for summer surface spill (#721) would also be adverse and negligible in the short or medium term as measures to prevent erosion and sedimentation would be implemented during construction.

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large and long-term recurring effects on water quality. The integrated temperature and habitat flow regime (#30a) would have beneficial minor, small, short- and long-term effects.

The Near-term Operations Measure would result in adverse minor, large, short- and long-term recurring effects; and beneficial negligible to minor, large, short- and long-term recurring effects.

It should be noted that for each these measures, water treatment at the drinking water facility would mitigate some of the effects of low-quality water. Without treatment, water quality effects would be a higher magnitude, duration or extent.

###### *3.19.5.7.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) basin-wide; maintenance of existing and new fish release sites above dams (#726) basin-wide; Operation, maintenance, repair, replacement and rehabilitation*

Maintenance and alteration of revetments (#9) and the maintenance of existing and new fish release sites (#726) would occur basin-wide. The effects would be adverse and negligible in magnitude as measures to prevent erosion and sedimentation would be implemented during construction. Effects would be small near the vicinity of the maintenance activities at the revetments and short term during construction. In the long term, the revetments would have no effects on drinking water and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects.

Construction effects of these measures would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

###### *3.19.5.7.2 Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) at Detroit; Green Peter; and Lookout Point dams; deeper fall reservoir drawdowns for fish passage (#40) at Blue River; Cougar; Detroit; Green Peter; Hills Creek; Lookout Point; spring reservoir drawdown for downstream fish passage (#720) at Cougar; Detroit; and Lookout Point dams; Fall Creek drawdown*

Using ROs to discharge cold water (#166) would have adverse effects on downstream water quality. The effects would be adverse minor, large, short and long term recurring during reservoir releases.

The reservoir drawdowns would have adverse effects on water quality downstream. The effects are minor, large, short and long term recurring in the fall and spring.

The spring reservoir drawdown for downstream fish passage (#720) would have a major, large, and short- and long-term effects on water availability. The deeper fall reservoir drawdowns for fish passage (#40) would have a negligible to minor, large, short- and long-term recurring effects.

Construction effects of the spring reservoir drawdown for downstream fish passage (#720) and deeper fall reservoir drawdown for fish passage (#40) would be adverse, negligible, small in the short or medium term as measures to prevent erosion and sedimentation would be implemented during construction.

*3.19.5.7.3 Use spillway for surface spill in summer (#721) at Blue River; Detroit; Foster; Green Peter; Hills Creek; and Lookout Point dams; Pass water over spillway in spring for fish passage (#714) at Big Cliff, Dexter, Falls Creek, Green Peter, and Hills Creek dams*

Using the spillway for summer surface spill (#721) and passing water over spillway in spring for fish passage (#714) would have beneficial and adverse minor effects to drinking water and public health and safety. The effects would be large affecting the entire reservoir and downstream receiving waters, short and long term recurring during summer and spring spillway releases.

Construction effects of using the spillway for summer surface spill (#721) would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

*3.19.5.7.4 Augment instream flows by using the inactive pool (#718) at Blue River, Cottage Grove; Dorena; and Falls Creek dams; Augment instream flows by using the power pool (#304) at Cougar, Detroit, Green Peter; Hills Creek; and Lookout Point dams*

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large, short- and long-term recurring effects on water quality.

*3.19.5.7.5 Integrated temperature and habitat flow regime (#30a) basin-wide*

Integrated temperature and habitat flow regime (#30a) would have beneficial effects on drinking water and public health and safety. The effects would be minor, small, short and long term.

*3.19.5.7.6 Construct adult fish facilities (#722) at Blue River; Green Peter; and Hills Creek dams; Pacific lamprey passage and infrastructure at Blue River; Green Peter; and Hills Creek dams; continued operation of existing adult fish facilities*

The construction effects of the construction of AFFs (#722) and providing Pacific lamprey passage and infrastructure (#52) would be adverse, negligible, small, short or medium term in duration. In the long term, there would be no effects to public health and safety associated with fish collection and fish passage infrastructure.

The continued operation of existing adult fish facilities would be adverse, negligible, small, short and long term recurring during the regular flushing of facilities during maintenance.

*3.19.5.7.7 Near-term Operations Measures*

The Near-term Operations Measures are a suite of operations measures in which the impacts were analyzed by grouping measures which include drawdowns utilizing the ROs and/or releasing water via the spillway. These measures would result in adverse minor, large, short- and long-term recurring effects; and beneficial negligible to minor, large, short- and long-term recurring effects.

##### *3.19.5.7.8 Climate Change*

Alternative 3A would improve fish passage by using operations-focused measures (using a deep drawdown to Cougars Dam's RO). The measures in Alternative 3A would improve water quality by normalizing temperatures. It would also provide fish passage with numerous deep drawdowns. Alternatives 3A and 3B would include more than twice as many drawdowns as the other alternatives, and Alternative 3A would include the less-deep drawdown to the Cougar RO. Due to the number of deep drawdowns, climate change would exacerbate the effects of Alternative 3A more than under Alternatives 1, 2A, 2B, 4, and 5, and less than Alternative 3B (but not appreciably). Climate change in combination with the measures under Alternative 3A would have adverse, moderate, large, long-term intermittent and/or permanent effects to drinking water.

#### ***3.19.5.8 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at COU)***

Under Alternative 3B, the effects to public health and safety - drinking would be the same as those described under Alternative 3A. Alternative 3B proposes the slightly different combination of operations for the downstream passage. Alternative 3A proposes the drawdown to 10 feet over the top of the Cougar Dam RO for deep fall and spring drawdown measures and 3B proposes drawdown utilizing the diversion tunnel at Cougar. The Near-Term Operations Measure(s) are also proposed under this alternative. The effects of the measures proposed under Alternative 3B are analyzed in this section. Effects are the similar to the effects described under the Discussion of Effects by Measure(s).

Alternative 3B effects are similar to 2B and 3A due to the spring drawdown. Effects would be adverse negligible, small, and short term or medium term for the construction and/or modification of any structural measures which include maintenance or alteration of revetments (#9); the maintenance of existing and new fish release sites (#726); construction of AFFs (#722); and providing Pacific lamprey passage and infrastructure (#52. Maintenance or alteration of revetments (#9); the maintenance of existing and new fish release sites (#726); construction of AFFs (#722) and providing Pacific lamprey passage and infrastructure (#52) have no long-term effects.

The effects of using ROs to discharge cold water (#166) would be adverse minor, large, short and long term recurring on water quality. Using the spillway for summer surface spill (#721) and passing water over spillway in spring for fish passage (#714) would have beneficial and adverse minor, large, short- and long-term recurring effects during summer and spring spillway releases. The reservoir drawdowns would have adverse, minor, large, short and long term recurring in the fall and spring. The spring reservoir drawdown for downstream fish passage (#720) would have a major, large, and short- and long-term effects on water availability. The deeper fall reservoir drawdowns for fish passage (#40) would have a negligible to minor, large, short- and long-term recurring effects. Construction effects the deeper fall reservoir drawdowns for fish passage (#40) and using the spillway for summer surface spill (#721) would also be adverse and negligible in the short or medium term as measures to prevent erosion and sedimentation would be implemented during construction.

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large and long-term recurring effects on water quality. The integrated temperature and habitat flow regime (#30a) would have beneficial minor, small, short- and long-term effects.

The Near-term Operations Measures would result in adverse minor, large, short- and long-term recurring effects; and beneficial negligible to minor, large, short- and long-term recurring effects.

It should be noted that for each these measures, water treatment at the drinking water facility would mitigate some of the effects of low-quality water. Without treatment, water quality effects would be a higher magnitude, duration or extent.

*3.19.5.8.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) basin-wide; Operation, maintenance, repair, replacement and rehabilitation*

Maintenance and alteration of revetments (#9) and the maintenance of existing and new fish release sites (#726) would occur basin-wide. The effects would be adverse and negligible in magnitude as measures to prevent erosion and sedimentation would be implemented during construction. Effects would be small near the vicinity of the maintenance activities at the revetments and short term during construction. In the long term, the revetments would have no effects on drinking water and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects.

Construction effects of these measures would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

*3.19.5.8.2 Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) at Detroit; Green Peter; and Lookout Point dams; deeper fall reservoir drawdowns for fish passage (#40) at Blue River; Cougar; Detroit; Green Peter; Hills Creek; Lookout Point and* *spring reservoir drawdown for downstream fish passage (#720) at Cougar; Detroit; and Lookout Point dams; Fall Creek drawdown*

Using ROs to discharge cold water (#166) would have adverse effects on downstream water quality. The effects would be adverse minor, large, short and long term recurring during reservoir releases.

The reservoir drawdowns would have adverse effects on water quality downstream. The effects are minor, large, short and long term recurring in the fall and spring.

The spring reservoir drawdown for downstream fish passage (#720) would have a major, large, and short- and long-term effects on water availability. The deeper fall reservoir drawdowns for fish passage (#40) would have a negligible to minor, large, short- and long-term recurring effects.

Construction effects of the spring reservoir drawdown for downstream fish passage (#720) and deeper fall reservoir drawdown for fish passage (#40) would be adverse, negligible, small in the short or medium term as measures to prevent erosion and sedimentation would be implemented during construction.

*3.19.5.8.3 Use spillway for surface spill in summer (#721) at Blue River; Detroit; Foster; Green Peter; Hills Creek; and Lookout Point dams; Pass water over spillway in spring for fish passage (#714) at Big Cliff, Detroit, Dexter, Lookout Point dams*

Using the spillway for summer surface spill (#721) and passing water over spillway in spring for fish passage (#714) would have beneficial and adverse minor effects to drinking water and public health and safety. The effects would be large affecting the entire reservoir and downstream receiving waters, and long term and recurring during summer and spring spillway releases.

Construction effects of this measure would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

*3.19.5.8.4 Augment instream flows by using the inactive pool (#718) at Blue River, Cottage Grove; Dorena; and Falls Creek dams; Augment instream flows by using the power pool (#304) at Detroit, Green Peter, Hills Creek, and Lookout Point dams*

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large, short- and long-term recurring effects on water quality.

##### *3.19.5.8.5 Integrated temperature and habitat flow regime (#30a) basin-wide*

Integrated temperature and habitat flow regime (#30a) would have beneficial effects on drinking water and public health and safety. The effects would be minor, small, short and long term.

##### *3.19.5.8.6 Construct adult fish facilities (#722) at Blue River; Green Peter; and Hills Creek dams; Pacific lamprey passage and infrastructure (#52) at Blue River; Green Peter; and Hills Creek dams; continued operation of existing adult fish facilities*

The construction effects of the construction of AFFs (#722) and providing Pacific lamprey passage and infrastructure (#52) would be adverse, negligible, small, short or medium term in duration. In the long term, there would be no effects to public health and safety associated with fish collection and fish passage infrastructure.

The continued operation of existing adult fish facilities would be adverse, negligible, small, short and long term recurring during the regular flushing of facilities during maintenance.

##### *3.19.5.8.7 Near-term Operations Measures*

The Near-term Operations Measures are a suite of operations measures in which the impacts were analyzed by grouping measures which include drawdowns utilizing the ROs and/or releasing water via the spillway. These measures would result in adverse minor, large, short- and long-term recurring effects; and beneficial negligible to minor, large, short- and long-term recurring effects.

##### *3.19.5.8.8 Climate Change*

Alternative 3B would improve fish passage by using operations-focused measures (using a deep drawdown to Cougars Dam's DT). The measures in Alternative 3B would improve water quality by normalizing temperatures and provide fish passage with numerous deep drawdowns. Alternatives 3A and 3B would include more than twice as many drawdowns as the other alternatives, and Alternative 3B would include the deeper drawdown to the Cougar DT. Climate change in combination with the measures under Alternative 3B would have adverse, moderate, large intermittent and/or permanent effects to drinking water in the long term.

#### *3.19.5.9 Alternative 4 – Structures-Based Fish Passage Alternative*

Under Alternative 4, a structures-based approach is proposed to improve fish passage. Alternative 4 is similar to Alternative 1. The Near-Term Operations Measure(s) are also proposed under this alternative.

The effects of the measures proposed under Alternative 4 are analyzed in this section. Effects are the similar to the effects described under the Discussion of Effects by Measure(s). Alternative 4 effects would be adverse negligible, small, and short term or medium term for the construction and/or modification of any structural measures which include maintenance or alteration of revetments (#9); the maintenance of existing and new fish release sites (#726); Foster fish ladder temperature improvement (#479); construction of WTC towers (#105); ; structural improvements to reduce TDG (#174); restoring upstream and downstream passage at drop structures (#639); construction of AFFs (#722); providing Pacific lamprey passage and infrastructure (#52); and construction structural fish passage infrastructure (#392). Maintenance or alteration of revetments (#9); the maintenance of existing and new fish release sites (#726); restoring upstream and downstream passage at drop structures (#639); construction of AFFs (#722); providing Pacific lamprey passage and infrastructure (#52); and construction structural fish passage infrastructure (#392) have no long-term effects. Foster fish ladder temperature improvement (#479) and construction of WTC towers (#105) would have beneficial, minor and long-term recurring effects.

The effects of using ROs to discharge cold water (#166) would be adverse minor, large, short and long term recurring on water quality. Using the spillway for summer surface spill (#721) and passing water over spillway in spring for fish passage (#714) would have beneficial and adverse minor, large, short- and long-term recurring effects during summer and spring spillway releases. Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large and long-term recurring effects on water quality. Construction effects of the using the spillway for summer surface spill (#721) would also be adverse and negligible in the short or medium term as measures to prevent erosion and sedimentation would be implemented during construction.

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large and long-term recurring effects on water quality. The integrated temperature and habitat flow regime (#30a) would have beneficial minor, small, short- and long-term effects.

The Near-term Operations Measure would result in adverse minor, large, short- and long-term recurring effects; and beneficial negligible to minor, large, short- and long-term recurring effects.

It should be noted that for each these measures, water treatment at the drinking water facility would mitigate some of the effects of low-quality water. Without treatment, water quality effects would be a higher magnitude, duration or extent.

##### *3.19.5.9.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) basin-wide; Operation, maintenance, repair, replacement and rehabilitation*

Maintenance and alteration of revetments (#9) and the maintenance of existing and new fish release sites (#726) would occur basin-wide. The effects would be adverse and negligible in magnitude as measures to prevent erosion and sedimentation would be implemented during construction. Effects would be and small near the vicinity of the maintenance activities at the revetments and short term during construction. In the long term, the revetments would have no effects on drinking water and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects.

Construction effects of these measures would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

*3.19.5.9.2 Foster Fish Ladder Temperature Improvement (#479); Construct WTC towers (#105) at Detroit; Hills Creek; and Lookout Point dams; Structural improvements to reduce TDG (#174) at Cougar; Detroit; Dexter; Foster; Green Peter; and Lookout Point dams*

Foster fish ladder temperature improvement (#479) would have beneficial effects. Construction of a new Forebay Warm Water Supply pipe would allow warmer surface from the Foster forebay to be released downstream, resulting in blending with cooler surface water. The effects would be beneficial, minor, large affecting the entire reservoir and downstream receiving waters, and long term and recurring during reservoir releases.

Structural improvements to reduce total dissolved gas (#174) would have adverse and minor, and large effects affecting the entire reservoir and the downstream receiving waters. The effects would be long term and permanent in duration.

Construction effects of these measures would be adverse negligible, small in the medium term as measures to prevent erosion and sedimentation would be implemented during construction.

*3.19.5.9.3 Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166) at Green Peter Dam; Fall Creek drawdown*

Using ROs to discharge cold water (#166) would have adverse effects on downstream water quality. The effects would be adverse minor, large, short and long term recurring during reservoir releases.

The Fall Creek reservoir drawdown would have adverse effects on water quality downstream. The effects are minor, large, short and long term recurring.

*3.19.5.9.4 Use spillway for surface spill in summer (#721) at Green Peter Dam*

Using the spillway for summer surface spill (#721) would have beneficial and adverse minor effects to drinking water and public health and safety. The effects would be large affecting the entire reservoir and downstream receiving waters, and long term and recurring during summer and spring spillway releases.

Construction effects of this measure would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

#### *3.19.5.9.5 Augment instream flows by using the inactive pool (#718) at Cottage Grove; Dorena; Falls Creek; and Blue River dams; Augment instream flows by using the power pool (#304) at Cougar; Detroit; Green Peter; Hills Creek; and Lookout Point dams*

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large, short- and long-term recurring effects on water quality.

#### *3.19.5.9.6 Integrated temperature and habitat flow regime (#30a) basin-wide*

Integrated temperature and habitat flow regime (#30a) would have beneficial effects on drinking water and public health and safety. The effects would be minor, small, short and long term.

#### *3.19.5.9.7 Restore upstream and downstream passage at drop structures (#639) at Fern Ridge Dam; construct AFF at Hills Creek Dam; provide Pacific lamprey passage and infrastructure at Fern Ridge and Hills Creek dams; and construct structural downstream fish passage Cougar; Detroit; Foster; Hills Creek; Lookout Point, Big Cliff and Dexter dams; continued operation of existing adult fish facilities*

The construction effects of restoring upstream and downstream passage at drop structures (#639) and would be negligible, small, in the short term. For the construction of AFFs (#722), providing Pacific lamprey passage and infrastructure (#52), and constructing structural downstream fish passage infrastructure (#392), construction effects would be negligible, small, short or medium term. In the long term, there would be no effects to public health and safety associated with fish collection, fish passage infrastructure and AFFs.

The continued operation of existing adult fish facilities would be adverse, negligible, small, short and long term recurring during the regular flushing of facilities during maintenance.

#### *3.19.5.9.8 Near-term Operations Measures*

The Near-term Operations Measures are a suite of operations measures in which the impacts were analyzed by grouping measures which include drawdowns utilizing the ROs and/or releasing water via the spillway. These measures would result in adverse minor, large, short- and long-term recurring effects; and beneficial negligible to minor, large, short- and long-term recurring effects.

#### *3.19.5.9.9 Climate Change*

Alternative 4 would improve fish passage with structures-based measures. The measures in Alternative 4 would improve water quality by reducing TDG and normalizing temperatures. Alternative 4 would not improve reservoir storage like Alternative 1, but it would feature fewer drawdowns than under all other action alternatives. Therefore, climate change would exacerbate the effects of Alternative 4 more than Alternative 1, but less than Alternatives 2A, 2B, 3A, 3B, and 5. Climate change in combination with the measures under Alternative 4 would have direct, adverse, minor, large, long-term intermittent and/or permanent effects to drinking water.

#### *3.19.5.10 Alternative 5 – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Under Alternative 5 – the Preferred Alternative, fish passage would be improved through a combination of modified operations and structural improvements. Alternative 5 is exactly the same as Alternative 2B except the integrated temperature and habitat flow regime (Measure #30a) is replaced with refined integrated temperature and habitat flow regime (Measure #30b). The Near-Term Operations Measure(s) are also proposed under this alternative. The effects of the spillway releases, flow/temperature modifications, fish infrastructure, drawdown operations, and the near-term operations measure under Alternative 5 are analyzed in this section. Effects are the similar to the effects described under the Discussion of Effects by Measure(s).

Alternative 4 effects would be adverse negligible, small, and short term or medium term for the construction and/or modification of any structural measures which include maintenance or alteration of revetments (#9); the maintenance of existing and new fish release sites (#726); Foster fish ladder temperature improvement (#479); construction of WTC towers (#105); construction of AFFs (#722) and construction structural fish passage infrastructure (#392). Maintenance or alteration of revetments (#9); the maintenance of existing and new fish release sites (#726; construction of AFFs (#722); (#52); and construction structural fish passage infrastructure (#392) have no long-term effects. Foster fish ladder temperature improvement (#479) and construction of WTC towers (#105) would have beneficial, minor and long-term recurring effects.

Using the spillway for summer surface spill (#721) and passing water over spillway in spring for fish passage (#714) would have beneficial and adverse minor, large, short- and long-term recurring effects during summer and spring spillway releases. Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large and long-term recurring effects on water quality. Construction effects of the using the spillway for summer surface spill (#721) would also be adverse and negligible in the short or medium term as measures to prevent erosion and sedimentation would be implemented during construction.

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large and long-term recurring effects on water quality. Refining the integrated temperature and habitat flow regime (#30b) would have beneficial minor, small, short- and long-term effects.

The Near-term Operations Measure would result in adverse minor, large, short- and long-term recurring effects; and beneficial negligible to minor, large, short- and long-term recurring effects.

It should be noted that for each these measures, water treatment at the drinking water facility would mitigate some of the effects of low-quality water. Without treatment, water quality effects would be a higher magnitude, duration or extent.

###### *3.19.5.10.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) basin-wide; Operation, maintenance, repair, replacement and rehabilitation*

Maintenance and alteration of revetments (#9) and the maintenance of existing and new fish release sites (#726) would occur basin-wide. The effects would be adverse and negligible in magnitude as measures to prevent erosion and sedimentation would be implemented during construction. Effects would be small near the vicinity of the maintenance activities at the revetments and short term during construction. In the long term, the revetments would have no effects on drinking water and public health and safety. Operation, maintenance, repair, replacement and rehabilitation would have adverse, negligible, small, short- or medium-term and long-term recurring effects.

Construction effects of these measures would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

###### *3.19.5.10.2 Foster Fish Ladder Temperature Improvement (#479); Construct WTC towers (#105) at Detroit Dam*

Foster fish ladder temperature improvement (#479) would have beneficial effects. Construction of a new Forebay Warm Water Supply pipe would allow warmer surface from the Foster forebay to be released downstream, resulting in blending with cooler surface water. The effects would be beneficial, minor, large affecting the entire reservoir and downstream receiving waters, and long term and recurring during reservoir releases.

The construction of WTC towers (#105) would have beneficial and adverse effects on water quality. The effects would be minor, large affecting the reservoir and downstream reaches, and long term and recurring when reservoir releases occur.

Construction effects of these measures would be adverse negligible, small in the medium term as measures to prevent erosion and sedimentation would be implemented during construction.

###### *3.19.5.10.3 Use spillway for surface spill in summer (#721) at Green Peter Dam*

Using the spillway for summer surface spill (#721) would have beneficial and adverse minor effects to drinking water and public health and safety. The effects would be large affecting the entire reservoir and downstream receiving waters, and long term and recurring during summer and spring spillway releases.

Construction effects of this measure would be adverse negligible, small in the short term as measures to prevent erosion and sedimentation would be implemented during construction.

*3.19.5.10.4 Augment instream flows by using the inactive pool (#718) at Blue River and Fern Creek dams; Augment instream flows by using the power pool (#304) at Detroit; Green Peter; Hills Creek; and Lookout Point dams; Fall Creek drawdown*

Augmenting instream flows by using the inactive pool (#718) and augmenting instream flows by using the power pool (#304) would have adverse negligible, small, short- and long-term recurring effects on water availability, and adverse minor, large, short- and long-term recurring effects on water quality.

The Fall Creek reservoir drawdown would have adverse effects on water quality downstream. The effects are minor, large, short and long term recurring.

*3.19.5.10.5 Refine integrated temperature and habitat flow regime (#30b) basin-wide*

Refining the integrated temperature and habitat flow regime (#30b) would have similar beneficial effects on drinking water and public health and safety as the integrated temperature and habitat flow regime (#30a). The effects would be minor and small affecting the downstream waters only, short and long term and recurring continually from February to November when base flow targets must be met, and from May to June for the temperature management flows.

*3.19.5.10.6 Construct AFF (#722) at Green Peter Dam; provide Pacific lamprey passage and infrastructure (#52) at Green Peter Dam; and construct structural downstream fish passage Detroit; Foster; Lookout Point, Big Cliff and Dexter dams; continued operation of existing adult fish facilities*

The construction effects of the construction of AFFs (#722), providing Pacific lamprey passage and infrastructure (#52), and constructing structural downstream fish passage infrastructure (#392) would be adverse, negligible, small, short or medium term in duration. In the long term, there would be no effects to public health and safety associated with fish collection and fish passage infrastructure.

The continued operation of existing adult fish facilities would be adverse, negligible, small, short and long term recurring during the regular flushing of facilities during maintenance.

*3.19.5.10.7 Near-term Operations Measures*

The Near-term Operations Measures are a suite of operations measures in which the impacts were analyzed by grouping measures which include drawdowns utilizing the ROs and/or releasing water via the spillway. These measures would result in adverse minor, large, short- and long-term recurring effects; and beneficial negligible to minor, large, short- and long-term recurring effects.

##### *3.19.5.10.8 Climate Change*

Alternative 5 is essentially the same as 2B. The measures in Alternative 5 would improve water quality by reducing TDG and normalizing temperatures. It would also provide fish passage. However, it would not improve reservoir storage like Alternative 1. Due to one more deep drawdown than Alternative 2A, climate change would exacerbate the effects of Alternative 5 more than Alternatives 1 or 2A. But overall, the effects would be the same as under Alternative 2A and 2B; climate change in combination with the measures under Alternative 5 would have direct, adverse, minor, large, long-term intermittent and/or permanent effects to drinking water.

#### ***3.19.5.11 Summary of Effects***

Alternative 1 would be the least severe because it would include only one recurring drawdown and would not include the suite of near-term operations. Alternative 1 is the only action alternative that would promote reservoir storage (i.e., from reducing minimum flows to congressionally authorized minimum flows) improving the availability of drinking water. Alternatives 2A and 2B effects are similar to one another with the exception of adverse major effects resulting from the spring drawdown. Alternative 3A and 3B have similar effects on water quality and water availability. Alternative 5 effects are less adverse than Alternative 4 because it does not include the use regulating outlets to discharge water during drawdowns and it includes structural improvements to reduce total dissolved gas which would have beneficial effects on water quality.

Overall, Alternatives 2B, 3A, and 3B would have the most adverse effects due to the spring drawdown as compared to Alternatives 1, 2A, 4, and 5. The spring drawdown would have a major effect on conservation pool storage because the spring drawdowns can affect the ability to refill system-wide storage.

## 3.20 ENVIRONMENTAL JUSTICE

The U.S. Environmental Protection Agency (EPA) defines environmental justice (EJ) as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies." The goal of "fair treatment" is not to shift risks among populations, but to identify potential disproportionately high and adverse impacts on minority and low-income communities and identify alternatives to mitigate any adverse impacts. The general principles for considering environmental justice under NEPA include (CEQ 1997a):

- Consideration of the affected area's composition to determine the presence of minority populations, low-income populations, or Indian Tribes that could be impacted by the proposed action and if so, whether there may be disproportionately high and adverse human health or environmental effects on these populations;
- Consideration of relevant data concerning the potential for multiple or cumulative exposure to human health or environmental hazards in the affected population and historical patterns of exposure to environmental hazards;
- Recognition of the interrelated cultural, social, occupational, historical, or economic factors that may enhance the natural and physical environmental effects of the proposed agency action;
- Development of effective public participation strategies by the agency;
- Ensuring meaningful community representation; and
- Ensuring adequate tribal representation during the process.

Executive Order 12898, Federal Actions to Address EJ in Minority Populations and Low-Income Populations, requires that federal agencies consider as a part of their action any disproportionately high and adverse human health or environmental effects to minority and low-income populations (collectively referred to as "communities with EJ concerns" or "populations with EJ concerns" throughout this section). Federal agencies are required to ensure that these potential effects are identified and addressed. For purposes of assessing EJ under NEPA, the Council on Environmental Quality (CEQ) defines a minority population as one in which the percentage of minorities exceeds 50 percent or is substantially higher than (or "meaningfully greater than") the percentage of minorities in the general population or other appropriate unit of geographic analysis (CEQ 1997a). Low-income populations are defined as households with incomes below the federal poverty level.

Potential impacts with the greatest intensity and longest duration would occur in counties comprising the Willamette Valley Basin (WVB), or where the Corps maintains and operates dams, reservoirs, fish passage facilities, fish hatcheries, or other structures that are part of the Willamette Valley System (WVS). Thus, the Region of Influence (ROI) for EJ includes the following counties:

- Benton County
- Clackamas County
- Columbia County
- Lane County
- Linn County
- Marion County
- Multnomah County
- Polk County
- Washington County
- Yamhill County

Other counties, such as Lincoln, Tillamook, and Douglas, contain only small portions of the WVB within their boundaries and do not contain structures (e.g., dams, reservoirs, fish passage facilities, hatcheries) that are operated and maintained by the Corps as part of the WVS, and are not impacted by the water resource management activities associated with the WVS. These counties are therefore not expected to be impacted by the Proposed Action and alternatives and are excluded from the ROI. For purposes of comparison, State of Oregon is defined as the region of comparison (ROC), or the "general population" as it corresponds to the CEQ definition. Note that because this Draft PEIS discusses general, qualitative effects from construction at the programmatic level, the above-listed counties and (as explained below) specific Tribes were chosen as the ROI and the State of Oregon or the respective county as the ROC. Site-specific project details for each construction measure will be determined during the implementation phase. Subsequent tiered NEPA documents would discuss detailed site-specific effects and conduct the EJ analysis on a smaller scale, and use census tracts or census blocks to further identify pockets of minority, low-income, and Native American communities that could be disproportionately affected by the proposed construction measures.

The CEQ EJ Guidance under NEPA recommends the identification of a geographic unit of analysis that accurately represents the occurrence and distribution of minority and low-income communities in the project area (CEQ 1997a). The Federal Interagency Working Group on EJ and NEPA Committee's Promising Practices for EJ Methodologies in NEPA Reviews notes that minority populations may reside in tightly clustered communities, or be evenly or unevenly distributed throughout the general population (FIWG on EJ & NEPA Committee 2016). Tribes that rely on the Willamette River for their subsistence needs were identified as communities with EJ concerns and were given the opportunity to be cooperating agencies for this project.

The CEQ EJ Guidance under NEPA also recommends identifying and describing human health, socioeconomic, and cultural vulnerabilities to define the affected environment (CEQ 1997a). This section considers these unique conditions of the Tribes and potential impacts from the alternatives as related to subsistence and ceremonial fishing. Section 3.12, Socioeconomic

Resources describes the socioeconomic impacts of the alternatives on the general population and Section 3.25, Cultural Resources describes impacts to cultural and historic properties and as such, this discussion will not be reiterated in this section.

U.S. Census Bureau (USCB) 2014-2019 American Community Survey (ACS) 5-year estimates are used to describe race and economic characteristics for the ROI and ROC. While 1-year ACS datasets were available for individual counties, this data was unavailable for the Tribes. To ensure that the most consistent and reliable income and demographic information is presented across populations with EJ concerns in the WVB, the ACS 5-year dataset was used.[58]

### 3.20.1 Minority Populations

The CEQ defines "minority" as including the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic Origin; or Hispanic (CEQ 1997a). The CEQ defines a minority population in the following ways:

- "…the minority population of the affected area exceeds 50 percent... (CEQ 1997a)." As this definition applies to the Proposed Action and alternatives, if more than 50 percent of the population in the ROI consists of minorities, this would qualify as constituting a population with EJ concerns.
- "…the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis (CEQ 1997a)." For purposes of this analysis, a discrepancy of 10 percent or more between minorities (the sum of all minority groups) in the ROI would be considered "meaningfully greater than" minorities in the State of Oregon, and would categorize the ROI as constituting a population with EJ concerns.

Table 3.20-1 shows the population broken down by race in the ROI and the ROC. The minority populations do not exceed 50 percent of the total population in any of the 10 counties included in the ROI. As such, none of the counties meet this regulatory definition of a minority population with EJ concerns.

In Benton, Clackamas, Columbia, Lane, Linn, Multnomah, Polk, and Yamhill counties, minorities represent 19.8, 18.1, 11.5, 18.2, 15.1, 30.3, 21.9, and 22.8 percent of the total population(s), respectively; in the State of Oregon, minorities represent 24.3 percent of the total population. A discrepancy of 10 percent or more between minorities (the sum of all minority groups) in these eight counties does not exist, therefore the representation of minorities in these counties is not considered "meaningfully greater than" the representation of minorities in the State of Oregon. As such, these eight counties do not meet this regulatory definition of a minority population with EJ concerns, either. However, as Table 3.20-1 indicates, Marion and Washington counties meet the regulatory definition of a minority population or minority group(s). Minorities in Marion County represent 34.5 percent of the total county population

[58] While ACS 5-year datasets are the least current, they are more reliable and use a larger sample size compared to 1-year estimates (USCB 2020a).

and minorities in Washington County represent 34.3 percent of the total county population, which is over 10 percent more than and considered “meaningfully greater than” the minority population in the state overall. By this CEQ definition of a minority population, Marion and Washington counties constitute populations with EJ concerns.

**Table 3.20-3.20-1. Summary of Minorities in the ROI and ROC in 2014 – 2019**

| Location | Total Population | Minority (%) | American Indian and Alaska Native (%) | Black or African American (%) | Asian (%) | Native Hawaiian and Other Pacific Islander (%) | Some Other Race (%) | Two or More Races (%) | Hispanic or Latino (%) |
|---|---|---|---|---|---|---|---|---|---|
| Benton County [a] | 91,107 | 19.8 | 0.5 | 1.0 | 7.1 | 0.2 | 0.2 | 3.4 | 7.4 |
| Clackamas County [a] | 410,463 | 18.1 | 0.6 | 0.9 | 4.2 | 0.2 | 0.1 | 3.3 | 8.7 |
| Columbia County [a] | 51,375 | 11.5 | 0.9 | 0.4 | 1.0 | 0.2 | 0.0 | 3.8 | 5.2 |
| Lane County[a] | 373,340 | 18.2 | 0.9 | 1.0 | 2.7 | 0.2 | 0.2 | 4.3 | 8.9 |
| Linn County [a] | 125,048 | 15.1 | 0.7 | 0.5 | 1.0 | 0.1 | 0.1 | 3.5 | 9.1 |
| Marion County [a] | 339,641 | 34.5 | 0.6 | 1.1 | 2.0 | 0.9 | 0.1 | 3.3 | 26.6 |
| Multnomah County [a] | 804,606 | 30.3 | 0.7 | 5.3 | 7.3 | 0.6 | 0.2 | 4.5 | 11.6 |
| Polk County [a] | 83,037 | 21.9 | 1.8 | 0.8 | 1.8 | 0.5 | 0.1 | 3.1 | 13.9 |
| Washington County [a] | 589,481 | 34.3 | 0.3 | 1.9 | 10.5 | 0.4 | 0.2 | 4.3 | 16.7 |
| Yamhill County [a] | 104,831 | 22.8 | 1.0 | 0.8 | 1.4 | 0.2 | 0.1 | 3.3 | 15.9 |
| State of Oregon [b] | 4,129,803 | 24.3 | 0.9 | 1.8 | 4.3 | 0.4 | 0.1 | 3.7 | 13.0 |

Sources: USCB 2019e

[a] ROI

[b] ROC

Note that the sum of vales for individual races and ethnicities may not add up to the total value shown in the “Minority (%)” column for some rows due to ± 0.1 percent margin of error in the dataset

### 3.20.2 Low-Income Populations

Low-income populations are defined as households with incomes below the federal poverty level. There are two slightly different versions of the federal poverty measure: poverty thresholds defined by the USCB and poverty guidelines defined by the Department of Health and Human Services (DHHS).

Poverty thresholds are defined by and updated each year by the USCB. The USCB uses a set of income thresholds that vary by family size and composition (number of children and elderly) to determine who is in poverty. If a family's total income is less than the family's threshold, then that family and every individual in it is considered in poverty. The same applies for a single individual. The official poverty thresholds do not vary geographically but are updated for inflation. The official poverty definition considers pre-tax income and does not include capital gains or non-cash benefits such as public housing, Medicaid, and food stamps (CEQ 1997a). Poverty thresholds are primarily used for statistical purposes, such as calculating poverty population figures or estimating the number of Americans in poverty each year. Poverty threshold figures are reported in the annual poverty report and provide a yardstick for progress or regress in antipoverty efforts. EJ Guidance Under NEPA recommends that USCB poverty thresholds be used to identify low-income populations (CEQ 1997a). As such, this section uses USCB poverty thresholds to identify low-income populations.

Because CEQ guidance does not specify a threshold for identifying low-income populations, the same approach used to identify EJ minority populations is applied to low-income populations. The ROI would be defined as a low-income population or population with EJ concerns if:

- More than 50 percent of the ROI consists of families or persons below the poverty threshold; or
- The percentage of low-income families or persons in the ROI is meaningfully greater than the percentage in the State of Oregon. A discrepancy of 10 percent or more between the ROI and the State of Oregon would be considered "meaningfully greater" and would categorize the ROI as constituting a low-income population with EJ concerns.

Table 3.20-2 provides income and poverty statistics for the ROI and the ROC. As Table 3.20-2 indicates, the percentage of all people and all families below the poverty threshold in the ROI is comparable to the State of Oregon's poverty levels. As such, the ROI does not have a substantially higher percentage of persons in poverty than the State of Oregon and does not qualify as a community with EJ concerns on this basis.

**Table 3.20-3.20-2. Summary of Income and Poverty Statistics in the ROI and ROC in 2014 – 2019**

| Location | People Below the Poverty Threshold (%) | Families Below the Poverty Threshold (%) |
|---|---|---|
| Benton County [a] | 19.1 | 8.3 |
| Clackamas County [a] | 8.0 | 5.2 |
| Columbia County [a] | 11.7 | 7.2 |
| Lane County [a] | 17.6 | 9.7 |
| Linn County [a] | 13.3 | 9.0 |
| Marion County [a] | 14.2 | 10.0 |
| Multnomah County [a] | 13.8 | 8.4 |
| Polk County [a] | 12.6 | 7.8 |
| Washington County [a] | 8.9 | 5.7 |
| Yamhill County [a] | 12.1 | 9.1 |
| State of Oregon [b] | 13.2 | 8.4 |

Sources: USCB 2019f; USCB 2019g

[a] ROI

[b] ROC

### 3.20.3 Native American Tribes

As described above, the CEQ EJ Guidance under NEPA recommends that when selecting a geographic unit of analysis for EJ, consideration should be given to the spatial distribution of minority and low-income populations, which may reside in tightly clustered communities or may be evenly or unevenly distributed throughout the general population. Per this guidance, the Corps has identified multiple federally-recognized Tribes that reside in concentrated “pockets” or reservations in and outside the WVB and that engage in unique cultural and traditional practices (subsistence and ceremonial fishing) that are directly dependent on the Willamette River, as shown in Figure 3.20-1 below. Note that while many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022). As noted above, these tribes were given the opportunity to be cooperating agencies for this project. The demographic and income information for these tribes is provided below and is compared to the corresponding county. Note here that each tribal reservation is considered the ROI, and each corresponding county is considered the ROC. Since these Tribes exist in tightly clustered communities, a county was considered to be an appropriate unit of comparison to accurately assess the demographic and income data for the Tribes impacted by the action alternatives.

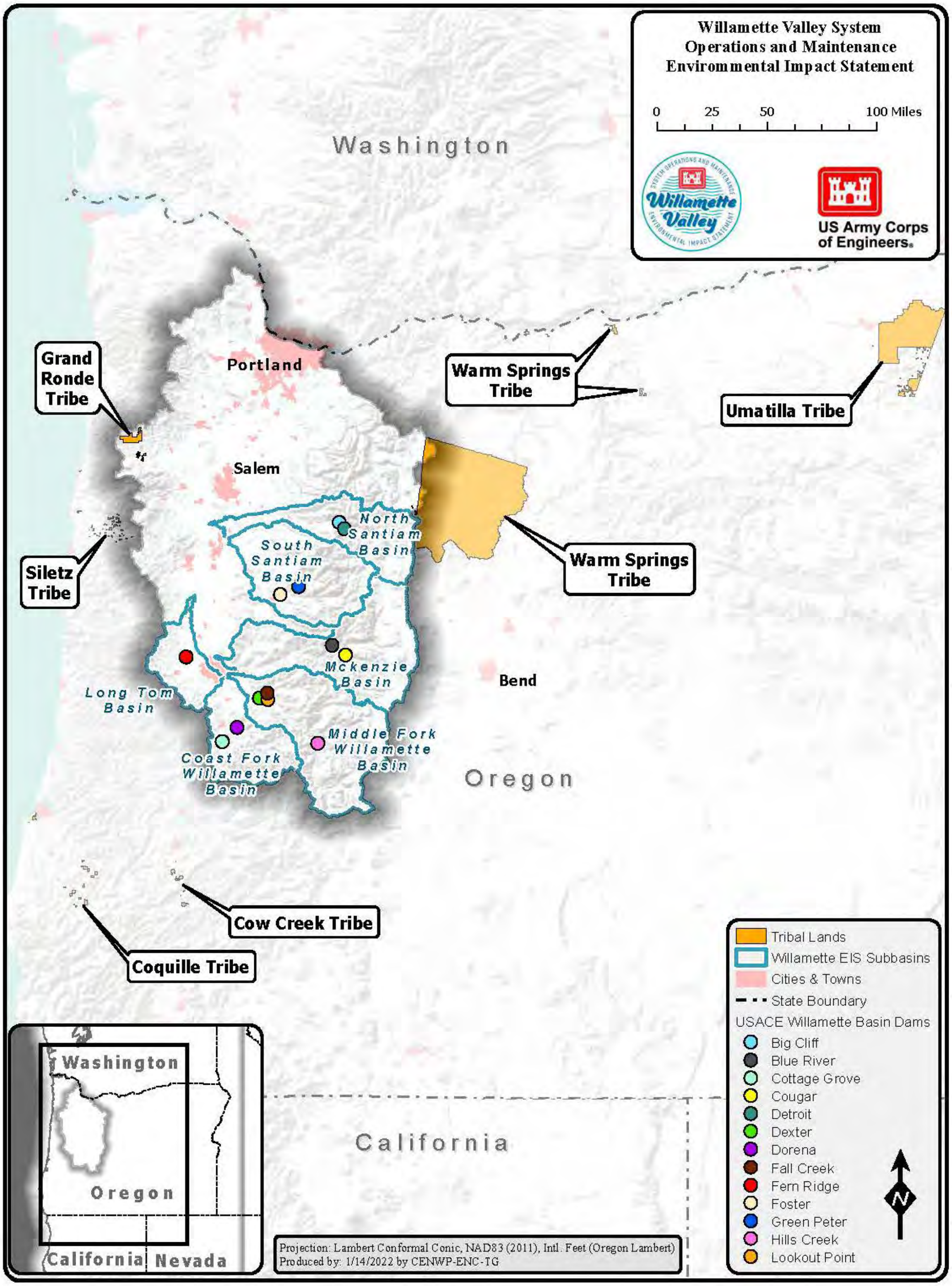


**Figure 3.20-1. Geographic Distribution of Tribal Land in and around the Willamette River Basin**

#### *3.20.3.1 Confederated Tribes of Grand Ronde Community of Oregon*

The Confederated Tribes of Grand Ronde is a community formed of more than 30 Tribes and bands from the Kalapuya, Mollala, Chasta, Umpqua, Rogue River, Chinook, and Tillamook, originating throughout western Oregon, northern California, and southwestern Washington. The entire WVS lies within the ceded lands of the 1855 treaties with the tribes and bands who were moved to the Grand Ronde reservation. Through the seven treaties listed in Chapter 7 Grand Ronde ancestors ceded all of the Willamette Valley and beyond for a significantly reduced reserve of tribal lands. The Tribal reservation extends over an area of 11,500 acres in Yamhill County, Oregon (CTGR No Date; CTGR 2014). The Tribe also owns off-reservation lands in Polk County. Members of the Confederated Tribes of Grand Ronde members live on the reservation and in off-reservation lands across the communities in and around the WVS (Grand Ronde, 2022).

Table 3.20-3 shows the population broken down by race on the Grand Ronde Community and Off-Reservation Trust Land (the ROI) and in the county where the Reservation is located (the ROC). As the table indicates, the Reservation meets the regulatory definition of a minority population because minorities represent more than 50 percent of its total population. By this CEQ definition of a minority population, the ROI constitutes a population with EJ concerns.

**Table 3.20-3.20-3. Summary of Minorities on the Grand Ronde Reservation and Trust Lands and Yamhill County in 2014 – 2019**

| Location | Total Population | Minority (%) | American Indian and Alaska Native (%) | Black or African American (%) | Asian (%) | Native Hawaiian and Other Pacific Islander (%) | Some Other Race (%) | Two or More Races (%) | Hispanic or Latino (%) |
|---|---|---|---|---|---|---|---|---|---|
| Grand Ronde Community and Off-Reservation Trust Land[a] | 586 | 88.4 | 67.1 | 0.7 | 0.5 | 0.3 | 0.1 | 10.2 | 9.6 |
| Yamhill County[b] | 104,831 | 22.8 | 1.0 | 0.8 | 1.4 | 0.2 | 0.1 | 3.3 | 15.9 |

Sources: USCB 2019h

[a] ROI

[b] ROC

Note that the sum of vales for individual races and ethnicities may not add up to the total value shown in the “Minority (%)” column for some rows due to ± 0.1 percent margin of error in the dataset

Table 3.20-4 shows income and poverty statistics for the Grand Ronde Community and Off-Reservation Trust Land (the ROI) and for the county where the Reservation is located (the ROC). As the table indicates, the percentage of all people and all families below the poverty threshold in the Reservation is 21.3 and 14.7 percent higher than in Yamhill County, respectively. As such, the ROI has a substantially higher percentage of all persons and all families in poverty than Yamhill County and qualifies as a community with EJ concerns on this basis.

**Table 3.20-3.20-4. Income and Poverty Statistics for the Grand Ronde Reservation and Trust Lands and Yamhill County in 2014 – 2019**

| Location | People Below the Poverty Threshold (%) | Families Below the Poverty Threshold (%) |
|---|---|---|
| Grand Ronde Community and Off-Reservation Trust Land[a] | 33.4 | 23.8 |
| Yamhill County[b] | 12.1 | 9.1 |

Sources: USCB 2019i; USCB 2019j

[a] ROI

[b] ROC

### 3.20.3.2 *Confederated Tribes of Warm Springs*

The Warm Springs Reservation, a 640,000-acre property in north central Oregon, is home to a confederation of three Tribes: Warm Springs, Wasco, and Paiute. The Warm Springs Tribe is made up of the Upper Deschutes (Tygh), Lower Deschutes (Wyam), Tenino, and John Day (Dock-spus) bands. The Wasco Tribe comprises the Dallas (Ki-gal-twal-la) and Dog River bands (CRITFC No Date). Historically, the Paiute territories included a large area from southeastern Oregon into Nevada, Idaho, and western Utah, though they eventually settled in Warm Springs and lived in Lake, Harney, and Malheur counties in Oregon (CTWS No Date).

Table 3.20-5 shows the population broken down by race on the Warm Springs Reservation and Trust Land (the ROI) and in the counties where the Reservation is located (the ROC). As the table indicates, the Reservation meets the regulatory definition of a minority population with EJ concerns because minorities represent more than 50 percent of its total population. By this CEQ definition of a minority population, the ROI constitutes a population with EJ concerns.

**Table 3.20-3.20-5. Summary of Minorities on the Warm Springs Reservation and Trust Lands and Jefferson and Wasco Counties in 2014 – 2019**

| Location | Total Population | Minority (%) | American Indian and Alaska Native (%) | Black or African American (%) | Asian (%) | Native Hawaiian and Other Pacific Islander (%) | Some Other Race (%) | Two or More Races (%) | Hispanic or Latino (%) |
|---|---|---|---|---|---|---|---|---|---|
| Warm Springs Reservation and Off-Reservation Trust Land[a] | 4,188 | 96 | 84.1 | 0.4 | 0.1 | 0.3 | 0.1 | 2.5 | 8.5 |
| Jefferson County[b] | 23,607 | 39.6 | 15.8 | 0.8 | 0.6 | 0.1 | 0.0 | 2.4 | 20 |
| Wasco County[b] | 26,130 | 25.4 | 3.0 | 0.3 | 0.9 | 0.6 | 0.0 | 2.5 | 18.2 |

Sources: USCB 2019k

[a] ROI

[b] ROC

Note that the sum of vales for individual races and ethnicities may not add up to the total value shown in the “Minority (%)” column for some rows due to ± 0.1 percent margin of error in the dataset

Table 3.20-6 shows income and poverty statistics for the Warm Springs Reservation and Off-Reservation Trust Land (the ROI) and for the counties where the Reservation is located (ROC). As the table indicates, the percentage of all people and all families below the poverty threshold in the Reservation is 14.4 and 15.5 percent higher than in Jefferson County, respectively. Also, the percentage of all people and all families below the poverty threshold in the Reservation is 20.7 and 19.6 percent higher than in Wasco County, respectively. As such, the ROI has a substantially higher percentage of all persons and families in poverty than Jefferson and Wasco Counties and also qualifies as a community with EJ concerns on this basis.

**Table 3.20-3.20-6. Income and Poverty Statistics for the Warm Springs Reservation and Trust Lands and Jefferson and Wasco Counties in 2014 – 2019**

| Location | People Below the Poverty Threshold (%) | Families Below the Poverty Threshold (%) |
|---|---|---|
| Warm Springs Reservation and Off-Reservation Trust Land[a] | 32.3 | 27.2 |
| Jefferson County[b] | 17.9 | 11.7 |
| Wasco County[b] | 11.6 | 7.6 |

Sources: USCB 2019l; USCB 2019m

[a] ROI

[b] ROC

### 3.20.3.3 *Confederated Tribes of Siletz Indians*

The Confederated Tribes of Siletz Indians is a confederation of 27 bands from western Oregon, Northern California, and Southern Washington. The Tribe owns and manages a 3,666-acre reservation along the Siletz River in Lincoln County, Oregon (NPAIHB No Date).

Table 3.20-7 shows the population broken down by race on the Siletz Reservation and off-Reservation Trust Land (the ROI) and in the county where the Reservation is located (the ROC). As the table indicates, the Reservation meets the regulatory definition of a minority population because minorities represent more than 50 percent of its total population. By this CEQ definition of a minority population, the ROI constitutes a population with EJ concerns.

**Table 3.20-3.20-7. Summary of Minorities on the Siletz Reservation and Trust Lands and Lincoln County in 2014 – 2019**

| Location | Total Population | Minority (%) | American Indian and Alaska Native (%) | Black or African American (%) | Asian (%) | Native Hawaiian and Other Pacific Islander (%) | Some Other Race (%) | Two or More Races (%) | Hispanic or Latino (%) |
|---|---|---|---|---|---|---|---|---|---|
| Siletz Reservation and Off-Reservation Trust Land[a] | 689 | 89.1 | 49.8 | 0.4 | 0.3 | 0.0 | 0.0 | 23.8 | 14.8 |
| Lincoln County[b] | 48,547 | 17.5 | 2.5 | 0.4 | 1.2 | 0.2 | 0.0 | 4.0 | 9.2 |

Sources: USCB 2019n

[a] ROI

[b] ROC

Table 3.20-8 shows income and poverty statistics for the Siletz Reservation and Off-Reservation Trust Land (the ROI) and for the county where the Reservation is located (the ROC). As the table indicates, the percentage of all people below the poverty threshold in the Reservation is 10.2 percent higher than in Lincoln County. The percentage of all families below the poverty threshold in the Reservation is 10.9 percent higher than in Lincoln County. As such, the ROI has a substantially higher percentage of all persons and families in poverty than Lincoln County and qualifies as a community with EJ concerns on this basis.

**Table 3.20-3.20-8. Income and Poverty Statistics of the Siletz Reservation and Trust Lands and Lincoln County in 2014 – 2019**

| Location | People Below the Poverty Threshold (%) | Families Below the Poverty Threshold (%) |
|---|---|---|
| Siletz Reservation and Off-reservation Trust Land[a] | 26.5 | 22.1 |
| Lincoln County[b] | 16.3 | 11.2 |

Sources: USCB 2019o; USCB 2019p

[a] ROI

[b] ROC

### 3.20.3.4 *Cow Creek Band of Umpqua Tribe of Indians*

The Cow Creek Band of Umpqua Tribe of Indians and its Reservation are located in Canyonville, Douglas County. Prior to 2018, the Tribe had approximately 4,471 acres of land held in trust. The Tribe uses this land to operate the Tribal government and Tribal-owned businesses (House Report 115-204 2017). In 2018, approximately 17,519 acres of timber land was reclassified from public domain lands to tribal lands and returned to the Cow Creek Tribe (Polcyn 2019; PL 115-103 HR 1306 2018). These lands are held in trust by the United States and are part of the Tribe's Reservation.

Table 3.20-9 shows the population broken down by race on the Cow Creek Reservation and Off-Reservation Trust Land (the ROI) and in Douglas County (the ROC). As the table indicates, minorities in the reservation represent 44.8 percent of its total population, which is 32.6 percent more than the minority population in Douglas County. By this CEQ definition of a minority population, the ROI constitutes a population with EJ concerns.

**Table 3.20-3.20-9. Summary of Minorities on the Cow Creek Reservation and Trust Lands and Douglas County in 2014 – 2019**

| Location | Total Population | Minority (%) | American Indian and Alaska Native (%) | Black or African American (%) | Asian (%) | Native Hawaiian and Other Pacific Islander (%) | Some Other Race (%) | Two or More Races (%) | Hispanic or Latino (%) |
|---|---|---|---|---|---|---|---|---|---|
| Cow Creek Reservation and Off-Reservation Trust Land[a] | 194 | 44.8 | 31.4 | 0.0 | 0.0 | 0.0 | 0.0 | 7.2 | 6.2 |
| Douglas County[b] | 109,114 | 12.2 | 0.9 | 0.4 | 1.0 | 0.1 | 0.1 | 3.9 | 5.8 |

Source: USCB 2019q

[a] ROI

[b] ROC

Table 3.20-10 shows income and poverty statistics for the Cow Creek Reservation and Off-Reservation Trust Land (the ROI) and for Douglas County (the ROC). As the table indicates, the percentage of all people below the poverty threshold on the Reservation is 12 percent higher than in the ROC. The percentage of all families below the poverty threshold in the Reservation is 11.8 percent higher than in the ROC. As such, the ROI has a substantially higher percentage of all persons and families in poverty than Douglas County and qualifies as a community with EJ concerns on this basis.

**Table 3.20-3.20-10. Income and Poverty Statistics of the Cow Creek Reservation and Trust Lands and Douglas County in 2014 – 2019**

| Location | People Below the Poverty Threshold (%) | Families Below the Poverty Threshold (%) |
|---|---|---|
| Cow Creek Reservation and Off-Reservation Trust Land[a] | 26.7 | 22.1 |
| Douglas County [b] | 14.7 | 10.3 |

Sources: USCB 2019r; USCB 2019s

[a] ROI

[b] ROC

### 3.20.3.5 *Confederated Tribes of the Umatilla Indian Reservation*

The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) is a union of three tribes: Cayuse, Umatilla, and Walla Walla. The Umatilla Indian Reservation is spread across approximately 172,000 acres in Umatilla County, Oregon (CTUIR No Date).

Table 3.20-11 shows the population broken down by race on the Umatilla Reservation and Off-Reservation Trust Land (the ROI) and in Umatilla County (the ROC). As the table indicates, minorities in the reservation represent 49.2 percent of its total population, which is 35 percent more than the minority population in Umatilla County. By this CEQ definition of a minority population, the ROI constitutes a population with EJ concerns.

**Table 3.20-11. Summary of Minorities on the Umatilla Reservation and Off-Reservation Trust Land and Umatilla County in 2014 – 2019**

| Location | Total Population | Minority (%) | American Indian and Alaska Native (%) | Black or African American (%) | Asian (%) | Native Hawaiian and Other Pacific Islander (%) | Some Other Race (%) | Two or More Races (%) | Hispanic or Latino (%) |
|---|---|---|---|---|---|---|---|---|---|
| Umatilla Reservation and Off-Reservation Trust Land Reservation[a] | 2,836 | 50.9 | 36.0 | 0.2 | 2.4 | 0.7 | 0.1 | 6.7 | 4.8 |
| Umatilla County[b] | 77,129 | 34.3 | 2.5 | 0.9 | 1.0 | 0.3 | 0.3 | 2.5 | 26.8 |

Source: USCB 2019t

[a] ROI

[b] ROC

Table 3.20-12 shows income and poverty statistics for the Umatilla Reservation and Off-Reservation Trust Land (the ROI) and in Umatilla County (the ROC). As the table indicates, the percentage of all people below the poverty threshold in the ROI is 16.6 percent and the percentage of all families below the poverty threshold in the ROI is 11.6 percent. As such, the ROI does not have a substantially higher percentage of all persons and families in poverty than Umatilla County and does not qualify as a community with EJ concerns on this basis.

**Table 3.20-12. Income and Poverty Statistics of the Umatilla Reservation and Off-Reservation Trust Land and Umatilla County in 2014 – 2019**

| Location | People Below the Poverty Threshold (%) | Families Below the Poverty Threshold (%) |
|---|---|---|
| Umatilla Reservation and Off-Reservation Trust Land Reservation[a] | 16.6 | 11.6 |
| Umatilla County[b] | 17.9 | 13.4 |

Sources: USCB 2019u; USCB 2019v

[a] ROI

[b] ROC

### 3.20.4 Environmental Effects

This section discusses the potential effects of the Proposed Action and alternatives on communities with EJ concerns, including Native American Tribes in the WVB. The discussion includes the methodology, the measures within the alternatives that were analyzed, a detailed analysis for each alternative, and a summary of the effects.

#### *3.20.4.1 Methodology*

Consideration of the potential consequences for environmental justice requires three main components, the first of which was done in the Affected Environment.

1. A demographic assessment of the affected community to identify the presence of minority populations, low-income populations, and Native American Tribes that may be affected.
2. An assessment of all potential impacts identified to determine if any could result in adverse impacts to the affected environment.
3. An integrated assessment to determine whether any disproportionately high and adverse impacts exist for minority populations, low-income populations, and Native American Tribes present in the ROI.

As discussed in Section 3.20.1, two counties in the ROI – Marion and Washington counties – constitute populations with EJ concerns because the percentage of minorities in these counties is meaningfully greater than the percentage of minorities in the corresponding ROC. The ROI does not qualify as a community with EJ concerns on the basis of low-income populations;

therefore, low-income communities are not discussed further in this section. The potential effect on the employment or general physical health and well-being of minority populations with EJ concerns in Marion and Washington counties is assessed. In general, the types of potential impacts on communities with EJ concerns could include:

- Social and economic benefits of direct, indirect and induced jobs created;
- Health risks (especially to workers) from the proposed construction and structural improvement activities;
- Noise disturbances;
- Restricted or delayed access to schools, residential areas, public transportation, or hospital and health care facilities due to traffic and time delays;
- Results of the RECONS (Regional ECONomic System) model with the number of jobs, labor income, gross regional product, and economic output supported by capital expenditures under each alternative are presented in Section 3.11.

Additionally, impacts on the harvest of fish species by Native American Tribes for subsistence, ceremonial, and traditional uses are also assessed separately based on harvest quantities, quality of the catch, ease of fishing, and the retention/loss of cultural and traditional values. Potential impacts to these Tribes are considered disproportionate not only because subsistence fishing is important for their survival, but also because these activities help to maintain and preserve their culture and tradition, play a key role in their local economies, and foster their overall physical and mental well-being.

Table 3.20-13 describes the evaluation criteria for the effect factors (magnitude, duration, and extent), and provides a definition for the scale of each effect factor.

**All comparisons of effects for each action alternative are in comparison to the NAA unless stated otherwise.**

**Table 3.20-13. Evaluation Criteria for Potential Effects to Environmental Justice**

| Effect Factor and Scale | Definition |
|---|---|
| **Magnitude** | |
| Negligible | No observable change to the physical or environmental health, general well-being, or socioeconomic status of minority populations in Marion and Washington counties with EJ concerns.<br>No observable change in the total annual subsistence and ceremonial catch numbers of fish species harvested by Tribes in the WVB or in the time required and the distance traveled to catch or harvest the same amount compared to current conditions. |

| Effect Factor and Scale | Definition |
|---|---|
| | Effects to both minority populations with EJ concerns in Marion and Washington counties and to Tribes would be considered disproportionately high, but would not be considered a significant. |
| Minor | Detectable change to the physical or environmental health, general well-being, or socioeconomic status of minority populations in Marion and Washington counties with EJ concerns.<br>Detectable change in the total annual subsistence and ceremonial catch numbers of fish species harvested by Tribes in the WVB or in the time required and the distance traveled to catch or harvest the same amount compared to current conditions.<br>Effects to both minority populations with EJ concerns in Marion and Washington counties and to Tribes would be considered disproportionately high, but would not be considered significant. |
| Moderate | Notable change to the physical or environmental health, general well-being, or socioeconomic status of minority populations in Marion and Washington counties with EJ concerns.<br>Notable change in the total annual subsistence and ceremonial catch numbers of fish species harvested by Tribes in the WVB or in the time required and the distance traveled to catch or harvest the same amount compared to current conditions.<br>Effects to both minority populations with EJ concerns in Marion and Washington counties and to Tribes would be considered disproportionately high, but would not be considered significant. |
| Major | Substantial change to the physical or environmental health, general well-being, or socioeconomic status of minority populations in Marion and Washington counties with EJ concerns, resulting in disproportionately high impacts to these populations. This would be considered a significant effect.<br>Substantial change in the total annual subsistence and ceremonial catch numbers of fish species harvested by Tribes in the WVB or in the time required and the distance traveled to catch or harvest the same amount compared to current conditions. Effects to Tribes would be disproportionally high and adverse. This would be considered a significant effect. |
| **Duration** | |
| Short term | Alteration lasts for the duration of small construction project, and is continuous for less than 2 years. |
| Medium term | Alteration is limited to the duration of large construction projects, and is continuous for a period of 2-5 years. |

| Effect Factor and Scale | Definition |
|---|---|
| Long term | Alteration is permanent or lasts continuously beyond operational changes or the completion of all construction projects; the alteration recurs at regular intervals (e.g., deep drawdowns that occur for a 3-week period in the fall and/or spring); or the alteration occurs intermittently. |
| **Extent** | |
| Small | Effects would be confined to the county where the dam/reservoir is located or to the Indian reservations and usual and accustomed places closest to the dam/reservoir. |
| Medium | Effects would occur in some counties or Indian reservations and usual and accustomed places. |
| Large | Effects would occur in all counties or Indian reservations and usual and accustomed places in the entire WRB. |

#### *3.20.4.2 Measures Analyzed for Environmental Justice*

Measures which could potentially directly or indirectly affect communities with EJ concerns if implemented under the considered alternatives include:

- Gravel augmentation below dams (#384)
- Adapt hatchery program (#719)
- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)
- Maintenance of existing and new fish release sites above dams (#726)
- Foster Fish Ladder Temperature Improvement (#479)
- Construct water temperature control tower (#105)
- Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166)
- Structural improvements to reduce TDG (#174)
- Augment instream flows by using the inactive pool (#718)
- Augment instream flows by using the power pool (#304)
- Integrated temperature and habitat flow regime (#30a)
- Refined integrated temperature and habitat flow regime (#30b)
- Restore upstream and downstream passage at drop structures (#639)
- Construct AFF (#722)
- Provide Pacific lamprey passage and infrastructure (#52)

- Construct structural downstream fish passage (#392)
- Deeper fall reservoir drawdowns for fish passage (#40)
- Spring reservoir drawdown for downstream fish passage (#720)
- Pass water over spillway in spring for fish passage (#714)
- Fall Creek Drawdown
- Continued operation of existing AFFs
- Operation, Maintenance, Repair, Replacement and Rehabilitation

Measures that would have no effect on communities with EJ concerns (and are therefore not discussed further) include:

- Use spillway for surface spill in summer (#721)
- Reduce minimum flows to Congressionally authorized minimum flow requirements (#723)

A summary of the environmental justice effects discussed in the sections below is provided in Table 3.20-14. Note that where a range of potential effects would occur, the most severe magnitude of adverse effects and the lesser magnitude of beneficial effects for each alternative was listed in this table. For example, if there is a range of minor to moderate adverse effects, moderate adverse effects are included in the table. If beneficial effects would range from minor to moderate, the table includes minor beneficial effects. Said otherwise, the most conservative conclusions of potential effects are presented in the table below in order to avoid overstating potential beneficial effects and understating adverse effects. Also, the extent of effects includes all reservoirs where potential effects would occur, even if the most severe adverse effect or the lesser beneficial effect does not occur at that reservoir. This follows the approach to present the most conservative conclusions in this table; instead of simply omitting reservoirs where less severe or more beneficial effects would occur. Discussion of all adverse and beneficial effects are included below.

**Table 3.20-14. Summary of Effects to Environmental Justice Under Each Alternative**

| Effect Factor | | Alternative | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NAA | 1 | 2A | 2B | 3A | 3B | 4 | 5 |
| **Short-Term** | | | | | | | | |
| Magnitude | Major adverse | Major adverse | Major adverse | Major adverse | Major adverse | Major adverse | Major adverse | Major adverse |
| Extent | Medium | Medium | Medium | Medium | Medium | Medium | Medium | Medium |
| **Medium-Term** | | | | | | | | |
| Magnitude | Minor adverse | Minor adverse | Minor adverse | Minor adverse | Moderate adverse | Moderate adverse | Moderate adverse | Moderate adverse |
| Extent | Large | Medium | Medium | Medium | Medium | Medium | Medium | Medium |
| **Long-Term (Permanent, Intermittent, or Recurring)** | | | | | | | | |
| Magnitude | Major adverse | Major adverse | Major adverse | Major adverse | Major adverse | Major adverse | Major adverse | Major adverse |
| Extent | Medium | Medium | Medium | Medium | Medium | Medium | Medium | Medium |
| Duration Type | Recurring | Recurring | Recurring | Recurring | Recurring | Recurring | Recurring | Recurring |

In the following subsections, the effects are discussed for the measures analyzed in the alternatives, for the No Action Alternative, and for each of the action alternatives.

#### *3.20.4.3 Discussion of Effects by Measure(s)*

This section applies the methodology described above to each measure analyzed for environmental justice to determine the potential effect. Where possible, discussion of similar measures that would have similar effects in terms of magnitude and durations are grouped together. The effects by measure or measures are then referenced in the effects analysis by alternative that follows. This Draft PEIS discusses general, qualitative effects from construction at the programmatic level. Site-specific project details for each construction measure will be determined during the implementation phase. Subsequent tiered NEPA documents would discuss detailed site-specific effects. And as explained above in the Affected Environment, subsequent tiered NEPA documents would use census tracts or census blocks to further identify pockets of minority, low-income, and Native American communities that could be affected by the proposed construction measures. The analysis in these tiered NEPA documents would include the effects analysis in this PEIS by reference as well as any additional, potential effects to newly identified communities with EJ concerns.

##### *3.20.4.3.1 Construction and/or Modification of Structural Measures*

This section discusses the potential impacts to communities with EJ concerns from the construction and/or modification of the structural measures shown below.

- Gravel augmentation below dams (#384)
- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)
- Construct water temperature control tower (#105)
- Structural improvements to reduce TDG (#174)
- Restore upstream and downstream passage at drop structures (#639)
- Construct AFF (#722)
- Provide Pacific lamprey passage and infrastructure (#52)
- Construct structural downstream fish passage (#392)
- Operation, Maintenance, Repair, Replacement and Rehabilitation

**Socioeconomic Effects**

The above listed construction and/or modification of structural measures would likely result in the creation of short- and medium-term jobs, which could be filled by minority populations. Although the majority of the construction labor would be sourced from specialized contractors located outside the ROI, these revenues would likely result in the creation of a relatively small number of construction jobs sourced from within the ROI. There would also be potential for the creation of a few full-time long-term operation and maintenance jobs to ensure the proper operation of these structures over the life of the project.

If minority populations in Marion and Washington counties are hired to work on these projects, they could experience negligible to minor health benefits through economic pathways in the short and medium term. Potential health impacts associated with increased employment overall could disproportionately benefit minority individuals hired to work on construction projects. Jobs and income are strongly associated with beneficial health outcomes such as an increase in life expectancy, improved child health status, improved mental health, and reduced rates of chronic and acute disease morbidity and mortality (HDA 2004; Cox et al. 2004).

Indirect economic impacts would also result from directly impacted industries (i.e., contractors) purchasing construction supplies and materials from other industries. Local vendors from whom construction companies would make purchases and local retail stores and establishments where the construction workers would shop would also benefit, potentially creating additional jobs. Induced impacts could also occur when employees of the directly and indirectly affected industries spend the wages they receive. The indirect and induced jobs that would be created would likely be relatively low-wage and low-skill jobs, such as restaurant workers or convenience store clerks.

The magnitude of the beneficial effects is contingent upon the level of expenditure associated with a given measure; larger expenditures will generate substantially larger direct, indirect, and induced economic impacts. Capital expenditures range from approximately $331 million to over $2 billion under the various alternatives. Therefore, the direct and indirect beneficial socioeconomic impact on communities with EJ concerns would range from negligible to minor in magnitude, and occur in the short term and medium term. However, these benefits would only persist for the duration of the construction and infrastructure improvement phases with only a small number of permanent maintenance jobs created; therefore, long-term beneficial effects would be negligible. Beneficial socioeconomic effects on communities with EJ concerns would be disproportionately high, but would not be significant.

**Noise Disturbances, Air Emissions, and Traffic**

Construction and/or structural modification projects would increase air emissions, noise levels, traffic, or visual disturbances at and near the project site in the short and medium term – less than two years or two to five years depending on the project (respectively). Thus, there may be negligible to minor adverse effects to the physical health and well-being of minority communities with EJ concerns that are hired to work at the sites for the duration of these projects. These effects would be disproportionately high and adverse, but would not be significant.

Residential development on most of the shores of most of the WVS reservoirs is minimal, including at Big Cliff, Blue River, Cottage Grove, Cougar, Dorena, Fall Creek, Green Peter, Hills Creek, and Lookout Point reservoirs. None of these reservoirs have towns on their shorelines.

Detroit, Dexter, Fern Ridge, and Foster reservoirs have the towns of Detroit, Lowell, Veneta, and Sweet Home on their shores, respectively, which range from populations of 192 to 10,000. The town of Detroit is in Marion County (which was identified above in Section 3.20.1 as having minority populations with EJ concerns), but the town of Detroit does not qualify as a population with EJ concerns. Following with the CEQ definition as explained in Section 3.20.1 and 3.20.2 Detroit does not qualify as having minority or low-income populations with EJ concerns by either definition. Minorities represent 2.4 percent of Detroit's population compared to 34.5 percent in Marion County; and 8.4 percent of Detroit's population lives at or below the poverty level compared to 14.2 percent in Marion County (USCB 2019e; USCB 2019f; USCB 2019w; USCB 2019x). Neither minorities nor low-income populations represent more than 50 percent of the total population in Detroit (USCB 2019w; USCB 2019x). Lowell and Veneta are in Lane County and Sweet Home is in Linn County, so discussion of disproportionately high impacts from noise disturbances, air emissions, or traffic to these towns from construction measures will be included in a tiered EA or EIS if after using census tracts or census blocks, they are identified as having populations with EJ concerns. As such, minority populations with EJ concerns in nearby residential communities are not discussed further in this PEIS.

**Subsistence Fishing and Tribal Effects**

The Corps has requested comments from the Grand Ronde, Coquille, Cow Creek, Klamath, Nez Perce, Umatilla, Warm Springs, Yakama, Confederated Tribes of the Coos, Lower Umpqua and Siuslaw (CTCLUSI), and Siletz Tribes. The CTCLUSI and Coquille Indian Tribe have deferred comments to the appropriate Tribe(s) because this Draft PEIS covers an area that is outside of their ancestral territory; none of their usual and accustomed places occur within the ROI for this Draft PEIS. The Corps is not currently aware of any subsistence fishing happening at or in the vicinity of the dams. However, in an effort to include as large a range as possible of potential effects in this Draft PEIS, a conservative approach was taken and it is assumed that Tribal subsistence fishing could occur at or in the vicinity of dams. The Final PEIS will be updated as appropriate based on information that is communicated by the Tribes.

If access to parts of the reservoir is restricted due to construction and/or modification projects where subsistence fishing occurs, there could be short and medium-term, adverse effects to Tribes. There would also be adverse impacts to Tribes that use the reservoirs for recreational purposes. If access to reservoirs is allowed when construction/structural improvement activities are taking place at those sites, Tribal communities with EJ concerns may experience short- or medium-term negligible to minor adverse impacts to their physical health and well-being from construction-related emissions, noise levels, and traffic. The magnitude would depend on the individual's proximity to the construction site. Disturbances during construction (including gravel augmentation and revetment alteration) may reduce the quantity and quality of some fish species available for harvesting due to increased turbidity from suspended sediment. Pacific lamprey is particularly sensitive to increases in turbidity and could experience respiratory distress, which may adversely impact their populations in the short or medium term and reduce their catch numbers (Lampman et al. 2021). Construction activities may also impact water quality downstream of the sites if fuel and chemical spills occur, which may contaminate the harvest and decrease its quality and quantity. As such, adverse effects to Tribal subsistence fishing and recreation could be minor in magnitude, and short-term and medium-term in duration. These effects would be disproportionately high and adverse, but would not be significant.

The implementation of measures discussed above would augment fish spawning and rearing habitat, improve instream water quality by ensuring instream temperature and TDG control, ensure adequate streamflow for biologically justified flows, and improve fish passage. These measures are not expected to lead to an increase in the availability of salmon, steelhead, lamprey, and other fish species for Tribal subsistence and ceremonial purposes, but would reduce the likelihood that the species would be in jeopardy of extinction. Fishing activities would not be restored at traditional sites currently abandoned by the Tribes due to dwindling fish populations. Members of the Tribes would still need to spend as much time and money as they presently do in order to travel to distant fishing sites to secure sufficient quantities of harvest. This would not help ease conflict between competing Tribes that are forced to share specific fishing sites; however, the continued existence of these fish species in the WRB would support the preservation of their cultural practices and pass on their knowledge of traditional fishing methods and customs to their youth. The implementation of these measures would not provide adequate food reserves for meetings, celebrations, and subsistence needs; Tribes would continue to rely on hatchery fish from ODFW facilities. While the implementation of the above measures would not result in overall beneficial effects to Tribal subsistence and ceremonial fishing activities, the effects would be less adverse than those currently experienced by Tribes due to dwindling fish populations in the WRB. Adverse effects would range from minor to moderate under the NAA and action alternatives in the long-term. These effects would be disproportionately high and adverse, but would not be significant.

###### *3.20.4.3.2 Implementation of Water Management Measures*

This section discusses the potential impacts to communities with EJ concerns from the implementation of the following water management measures:

- Adapt hatchery program (#719)
- Maintenance of existing and new fish release sites above dams (#726)
- Foster Fish Ladder Temperature Improvement (#479)
- Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166)
- Augment instream flows by using the inactive pool (#718)
- Augment instream flows by using the power pool (#304)
- Integrated temperature and habitat flow regime (#30a)
- Refined integrated temperature and habitat flow regime (#30b)
- Deeper fall reservoir drawdowns for fish passage (#40)

- Spring reservoir drawdown for downstream fish passage (#720)
- Pass water over spillway in spring for fish passage (#714)
- Fall Creek Drawdown
- Continued operation of existing AFFs

**Socioeconomic Effects**

Adverse economic effects associated with drawdowns are discussed at length throughout the socioeconomics section, beginning in Section 3.11.2.4.2 (Alteration of outflows and reservoir levels/Recreational Value), and is summarized briefly here as it applies to populations with EJ concerns. Drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. These short- and long-term recurring adverse effects would range from minor to major. The magnitude of effects under each alternative would depend on the number of drawdowns per year and the number of reservoirs at which they would occur. These effects would be adverse and disproportionate to populations with EJ concerns that are located in the county where drawdowns would occur or that are economically dependent on the reservoir where the drawdowns would occur. Disproportionately high and adverse effects that are major in magnitude would be considered a significant effect.

As described in 3.20.3, the Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Cow Creek Band of Umpqua Tribe of Indians, and Confederated Tribes of the Umatilla Indian Reservation are located in Yamhill, Jefferson and Wasco, Wasco, Lincoln, and Lincoln counties (respectively). Drawdowns are not proposed at any of the reservoirs located in the aforementioned counties. However, as noted above, while many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022). As such, drawdowns under all alternatives could adversely and disproportionately affect tribal members throughout the WVS that are economically dependent on the reservoirs where drawdowns are proposed.

**Subsistence Fishing and Tribal Effects**

Reservoir drawdowns would result in high rates of sediment transport from the reservoir and high turbidity levels in areas downstream; and cause minor adverse effects to Tribal subsistence fishing activities. As described above, Pacific lamprey is particularly sensitive to increases in turbidity and could experience respiratory distress, which may adversely affect their populations in the short term and reduce their catch numbers (Lampman et al. 2021). These minor adverse effects would also be long-term and recurring because while the drawdown would only be held for three weeks, it would occur annually. These effects to Tribal subsistence fishing would be disproportionately high and adverse, but would not be significant.

As discussed at length in Section 3.14 (Recreation), it is assumed that the majority of recreationists would forgo visiting the reservoir during drawdowns; which would have a major and adverse effect on all recreationists, including Tribal recreationists. For those that continue to visit reservoirs during drawdowns, adverse effects would also be major because visually drawdowns would be very noticeable, and would substantially impact the recreational experience – including that of Tribal members. These effects would occur in the short term during the three-week drawdown and recur in the long term. These disproportionately high and major, adverse effects would be considered significant.

Similar to the construction and/or modification of structural measures, implementation of water management measures listed above – but in particular the use of water from inactive pool or power pool to increase river flows and reservoir drawdowns in spring and fall seasons – would boost fish populations downstream of the reservoirs by increasing the survival and passage rate of fish species during their downstream passage. This would have beneficial effects to Tribes engaging in subsistence fishing activities downstream of the affected reservoirs in the long term. Fishing activities would not be restored at traditional sites currently abandoned by the Tribes due to dwindling fish populations. Members of the Tribes would still need to spend as much time and money as they presently do in order to travel to distant fishing sites to secure sufficient quantities of harvest. This would not help ease conflict between competing Tribes that are forced to share specific fishing sites. However, the continued existence of these species – or more precisely, their respective evolutionarily significant units (ESUs) and distinct population segments (DPSs) – in the WRB would support the preservation of their cultural practices and pass on their knowledge of traditional fishing methods and customs to their youth. The implementation of these measures would not provide adequate food reserves for meetings, celebrations, and subsistence needs; Tribes would continue to rely on hatchery fish from ODFW facilities. While the implementation of the above measures would not result in overall beneficial impacts to Tribal subsistence and ceremonial fishing activities, effects would be less adverse than those that are currently experienced by Tribes due to dwindling fish populations in the WRB. Overall, adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would range from minor to moderate in magnitude and long-term in duration. These effects would be disproportionately high and adverse, but would not be significant.

#### *3.20.4.3.3 Suite of Near-term Operations*

Near-term operations that could affect environmental justice include deep drawdowns and extended deep drawdowns, RO prioritization, and delayed reservoir refills for improved downstream fish passage. Similar to the effects discussed in Section 3.20.4.3.2, extended deep drawdowns and delayed reservoir refills would also cause adverse effects to Tribal fishing activities downstream of reservoirs; and would be minor, short-term and long-term recurring. These effects would be disproportionately high and adverse, but would not be significant. Adverse effects to Tribal recreation would be major and adverse due to the reservoir drawdowns. These disproportionately high and major, adverse effects would be considered significant. These effects would still be small in extent, and short-term and long-term recurring.

The suite of near-term operations would further augment fish spawning and rearing habitat, improve instream water quality by ensuring instream temperature and TDG control, ensure adequate streamflow for biologically justified flows, and improve fish passage. While the implementation of the suite of near-term operations would not result in overall beneficial impacts to Tribal subsistence and ceremonial fishing activities, Tribes, in general, would experience less adverse impacts than the adverse effects they presently experience due to dwindling fish populations in the WRB. These effects would be negligible in magnitude and long-term in duration. And while effects would be disproportionately high and adverse, they would not be considered significant.

### *3.20.4.4 No Action Alternative (NAA)*

Under the NAA, current actions within the WVS and the conditions that would result from continued O&M and Fall Creek drawdown would persist.

#### *3.20.4.4.1 Socioeconomic Effects; Noise Disturbance, Air Emissions, and Traffic*

Additional construction jobs would be created during routine and non-routine maintenance or major maintenance and rehabilitation projects, resulting in negligible beneficial effects in the short and medium term. If minority populations with EJ concerns in Marion and Washington counties are hired to work on these projects, they could experience negligible health benefits through economic pathways in the short and medium term. Potential health effects associated with increased employment overall could disproportionately benefit minority individuals hired to work on non-routine maintenance projects. As described above in Section 3.20.4.3.1, jobs and income are strongly associated with a number of beneficial health outcomes such as an increase in life expectancy, improved child health status, improved mental health, and reduced rates of chronic and acute disease morbidity and mortality (HDA 2004; Cox et al. 2004). Beneficial socioeconomic effects on communities with EJ concerns would be disproportionately high, but would not be significant. Major maintenance and rehabilitation projects would increase air emissions, noise levels, traffic, or visual disturbances at and near the project site and cause negligible to minor, medium-term adverse effects to the physical health and well-being of communities with EJ concerns hired to work at the project. The extent of effects would be small and would only affect workers at the project location. These effects would be disproportionately high and adverse, but would not be significant.

As discussed in 3.20.4.3.2, drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. The Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Cow Creek Band of Umpqua Tribe of Indians, and Confederated Tribes of the Umatilla Indian Reservation are not located in Lane County, where the Fall Creek Drawdown occurs. However, as noted above, while many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022). As such, drawdowns could adversely and disproportionately affect tribal members throughout the WVS that are economically dependent on the Fall Creek Reservoir. Given that one drawdown would occur annually in one county, the magnitude of effects would be minor and extent of the extent would likely be medium under this alternative, occurring in some of the counties in the WVS. These effects would be disproportionately high and adverse, but would not be significant.

#### *3.20.4.4.2 Subsistence Fishing and Tribal Effects*

During major maintenance and rehabilitation projects, there would be minor adverse impacts to Tribes as subsistence fishing activities and recreation may be restricted in the medium term. If access to impacted reservoirs is allowed, Tribal communities with EJ concerns may experience medium-term negligible to minor adverse impacts to their physical health and well-being from construction-related emissions, noise levels, and traffic, depending on the individual's proximity to the construction site and the size of the project (i.e., routine maintenance versus major rehabilitation project). Disturbances during maintenance/rehabilitation projects, gravel augmentation, revetment alteration, and the Fall Creek Drawdown may reduce the quantity and quality of fish available for harvesting for some species due to increased turbidity from suspended sediment, as discussed above in Section 3.20.4.3.1. Pacific lamprey is particularly sensitive to increases in turbidity and could experience respiratory distress, which may adversely impact their populations in the short or medium term and reduce their catch numbers (Lampman et al. 2021). Construction activities may also impact water quality downstream of the sites if fuel and chemical spills occur, which may contaminate the harvest and decrease its quality and quantity at the usual and accustomed fishing areas in the vicinity of the impacted reservoirs. As such, adverse effects to Tribal subsistence fishing could be negligible to minor in magnitude, short-term and medium-term in duration, and large in extent. Effects from major maintenance and rehabilitation projects are expected to occur intermittently over the period of analysis of this Draft PEIS. These effects would be disproportionately high and adverse, but would not be significant.

The Fall Creek drawdown would also have adverse and major effects to Tribal recreationists at Fall Creek. Some recreationists would forego visitation to the reservoir altogether during the drawdowns. Others that continue to visit the reservoir during drawdowns would be adversely affected due to visual effects on the recreational experience. Effects would occur in the short term and recur in the long term. The extent of effects would be small because they would only occur at Fall Creek. These disproportionately high and major, adverse effects would be considered significant.

Historically, WVB supported abundant salmon returns and provided the Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Confederated Tribes and Bands of the Yakama Nation, Nez Perce Tribe, Cow Creek Band of Umpqua Tribe, and the Umatilla Tribe with a reliable, year-round source of protein. Today, fishing in the Willamette River and its tributaries continues to be an important practice providing sustenance to many Native communities and forming the foundation for many cultural and religious practices among these Tribes. However, the construction and operation of the WVS dams has led to declines in fish populations over the past few decades and has driven some species of salmon and steelhead to eminent risk of extinction, prompting federal and state agencies to set limits on the quantities of fish that can be harvested for commercial, recreational, and other purposes. For example, the Grand Ronde community can harvest up to 15 salmonids annually for ceremonial purposes at Willamette Falls (OAR 635-041-0610 No Date). Many streams in WRB no longer have harvestable populations of salmon, steelhead, and lamprey. Since traditional fishing areas are quickly disappearing, many Tribes are forced to travel greater distances and rely on fishing sites already heavily in use by several other Tribes, such as Willamette Falls, leading to competition between Tribes. The intense supplementation of hatchery fish has deteriorated the genetic integrity and viability of native fish populations. These factors have impacted the quality and quantity of fish populations available to the Tribes for subsistence and ceremonial harvesting purposes (Emery No Date; CTGR 2014).

With the decline in fish populations in WRB, the Tribes are losing a critical resource that sustains their traditions and way of life. With fewer quantities of fish available for harvest, many young Tribal members do not know how to harvest or prepare historically important subsistence foods (CTGR 2014). Earlier, celebrations surrounding First Salmon Ceremonies, events honoring the return of salmon to their freshwater habitat, would be timed with the spring arrival of salmon to the Tribal groups along the Willamette River. Now, many Tribes plan these ceremonies months in advance given uncertainties about if or when salmon might return from their migration from the ocean through the Willamette hydrosystem to the Tribal fishing sites (Emery No Date).

Under the NAA, the current operating conditions of the WVS would continue and would not adequately benefit the fish species essential to meet the subsistence and ceremonial requirements of the Tribes in the ROI. If fish populations in the WRB continue to decline, the number of traditional fishing sites could decline further, prompting Tribal members to spend more time and money to travel greater distances to suitable fishing sites. This could increase competition between Tribes, leading to fewer fish allocations by ODFW for ceremonial and subsistence purposes. Currently, certain Tribes such as the Grand Ronde Community and Siletz Indians receive up to 4,000 pounds of chinook salmon and salmon carcasses respectively for subsistence purposes from State of Oregon Fisheries (CTGR 2014; Siletz Tribal Code § 7.001 2017; CTSI No Date). The continued decline in fish populations in WRB could make the Tribes more reliant on the fish supplies from ODFW fish hatcheries, which are genetically different from the wild-caught fish species that the Tribes rely on. Overall, this could result in the loss of Tribal culture and traditions that are driven by the harvest of these fish species. As such, impacts to Tribes engaged in subsistence and ceremonial fishing in the ROI would be adverse, moderate in magnitude, long-term in duration, and large in extent. These effects would be disproportionately high and adverse, but would not be significant.

##### *3.20.4.4.3 Climate Change*

Climate change would adversely affect Tribal subsistence fishing, decreasing fish populations and therefore fish available for harvest. All of the climate change factors listed in Section

3.1.2.3 would affect water temperatures, flow regime, hydrology and ecosystem processes; increase exposure of fish to diseases and parasites; and increase the prevalence of invasive species, thereby leading to changes in population, habitat quality and quantity, and distribution of fisheries resources harvested by subsistence communities (ODFW No Date). Higher air and water temperatures, less water in river and reservoir systems, and more frequent and severe wildfires would decrease water quality from higher turbidity and increased occurrence of HABs (which would decrease dissolved oxygen (DO) concentrations and could adversely affect fish populations).

Under the NAA, adverse effects to Tribal subsistence fishing could be minor in the short and medium term and large in extent. Climate change could exacerbate effects from maintenance/rehabilitation projects, gravel augmentation, revetment alteration, and the Fall Creek Drawdown, as increased wildfire ash, HABs, and erosion would further increase turbidity and could further reduce the quantity and quality of some fish species available for harvest. As such, the effects of climate change and the measures under the NAA would be minor to moderate in the short and medium term and large in extent. These effects would be disproportionately high and adverse, but would not be significant.

Under the NAA, adverse effects to Tribal recreation would be major and adverse due to the Fall Creek drawdown. Climate change would further reduce water quantity with higher air and water temperatures and if there is less water in river and reservoir systems. Overall effects from climate change and the measures under the NAA would still be major in the short term and recur in the long term; and be small in extent. These disproportionately high and major, adverse effects would be considered significant.

Under the NAA, potential effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would be adverse, moderate in magnitude, long-term in duration, and large in extent. All of the climate change factors listed in Section 3.1.2.3 would likely further decrease the fish species available for harvest, disrupting subsistence harvest patterns and the seasonality of harvest activities and locations of fishing areas, and inducing stress within or between communities by adversely impacting subsistence resource sharing activities. As such, the measures under the NAA in combination with climate change on subsistence, ceremonial, and traditional fishing activities of Native American Tribes reliant on fish in the WVB would be moderate to major in magnitude, large in extent, and long-term in duration. Disproportionately high and adverse effects that are major in magnitude would be considered a significant effect.

#### *3.20.4.5 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Alternative 1 consists of structural improvements and management measures which maximize refill volumes of conservation pools at WVS reservoirs in support of improved survival of ESA-listed fish species in addition to other authorized project purposes of the structures. Under Alternative 1, measures at and in the vicinity of dam sites/reservoirs would occur as follows:

Construction/modification of structural measures:

- Gravel augmentation below dams (#384) would occur at CGR, BLU, FOS, and BCL;
- Maintenance or alteration of revetments (#9) would occur basin wide;
- Construction of water temperature control tower (#105) would occur at LOP, GPR, and DET;
- Structural improvements to reduce TDG (#174) would occur at DEX, LOP, CGR, FOS, GPR, and DET;
- Restoration of upstream and downstream passage at drop structures (#639) would occur at FRN;
- Construction of adult fish facility (#722) would occur at GPR;
- Provision of Pacific lamprey passage and infrastructure (#52) would occur at FRN and GPR;
- Construction of structural downstream fish passage (#392) would occur at LOP, FOS, GPR, and DET; and
- Operation, Maintenance, Repair, Replacement and Rehabilitation would occur basin wide.

Operation of structural measures mentioned above and implementation of water management measures would occur as follows:

- Adaptation of Hatchery Program (#719) would occur at DEX, LOP, FCR, HCR, CGR, BLU, FOS, GPR, BCL, and DET;
- Maintenance of existing and new fish release sites above dams (#726) would occur at LOP, FCR, HCR, CGR, FOS, GPR, BCL, and DET;
- Fish ladder temperature improvement (#479) would occur at FOS;
- Augmentation of instream flows by using the inactive pool (#718) would occur at CTG, DOR, FCR and BLU;
- Augmentation of instream flows by using the power pool (#304) would occur at LOP, HCR, CGR, GPR, and DET;
- Fall Creek Drawdown would occur at FCR; and
- Continued operation of existing AFFs would occur at DEX, FCR, CGR, FOS, and BCL

###### *3.20.4.5.1 Socioeconomic Effects; Noise Disturbance, Air Emissions, and Traffic*

The direct, indirect, and induced socioeconomic effects to communities with EJ concerns due to the creation of construction jobs, impacts to the health of workers hired from communities with EJ concerns and communities with EJ concerns residing in the vicinity of the impacted reservoirs from air emissions and increased noise levels during construction/structural improvement activities, and traffic/transportation impacts during construction are described in Section 3.20.4.3.1.

Construction expenditures associated with Alternative 1 are expected to total approximately $1.8B. As such, the direct, indirect, and induced socioeconomic impact of Alternative 1 on minority communities with EJ concerns would be beneficial, minor in magnitude, occur in the short-term and medium-term, and be medium in extent. Beneficial socioeconomic effects on communities with EJ concerns would be disproportionately high, but would not be significant. The adverse health effects from construction and infrastructure improvement activities on communities with EJ concerns hired to work at the project locations would be minor; and occur in the short-term and medium-term. The extent of effects would be small and would only affect workers at the project location. These effects would be disproportionately high and adverse, but would not be significant.

Construction and infrastructure improvement activities under Alternative 1 would occur at locations spread across three counties – namely Marion, Linn, and Lane counties. It is assumed that if a project occurs in one of these three counties, many of the local workers hired to support the project would be from that county. Since Marion County constitutes an EJ minority population, the impacts to populations with EJ concerns in Marion County from activities proposed under this alternative would be markedly greater than outlying areas. Construction workers from Marion County may also be hired to work at locations in nearby Linn County. Impacts to minority communities with EJ concerns in Washington County, which is the only other county that constitutes a population with EJ concerns in the ROI, would be less pronounced since no project measures would be implemented in this county. However, construction workers from Washington County may be hired to work on projects in the nearby Marion County.

As discussed in 3.20.4.3.2, drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. The Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Cow Creek Band of Umpqua Tribe of Indians, and Confederated Tribes of the Umatilla Indian Reservation are not located in Lane County, where the Fall Creek Drawdown occurs. However, as noted above, while many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022). As such, drawdowns could adversely and disproportionately affect tribal members throughout the WVS that are economically dependent on the Fall Creek Reservoir. Given that one drawdown would occur annually in one county, the magnitude of effects would be minor and the extent would likely be medium under this alternative, occurring in some of the counties in the WVS. These effects would be disproportionately high and adverse, but would not be significant.

##### *3.20.4.5.2 Subsistence Fishing and Tribal Effects*

The construction/modification of structural measures; major maintenance and rehabilitation projects; gravel augmentation and maintenance of revetments; and Fall Creek drawdown would increase turbidity and may reduce the quantity and quality of some fish species available for harvesting.

As such, adverse effects from construction and/or structural modification projects as well as the Fall Creek drawdown to Tribal subsistence fishing activities and recreation as described in Section 3.20.2.3.1 would be minor in magnitude; short-, medium-, and long-term recurring in duration; and medium in extent. Effects from major maintenance and rehabilitation projects are expected to occur intermittently over the period of analysis of this Draft PEIS. These effects would be disproportionately high and adverse, but would not be significant.

As discussed under in Section 3.20.4.3.2 and the NAA, the Fall Creek drawdown would also have adverse and major effects to Tribal recreationists. Some recreationists would forego visitation to the reservoir altogether during the drawdowns. Others that continue to visit the reservoir during drawdowns would be adversely affected due to visual effects on the recreational experience. Effects would occur in the short term and recur in the long term. The extent of effects would be small because they would only occur at Fall Creek. These disproportionately high and major, adverse effects would be considered significant.

Impacts to Tribes that fish for subsistence purposes near the project locations or that fish recreationally at the reservoirs in the three counties mentioned above would be markedly greater than outlying areas and are described in Section 3.20.4.3. The Confederated Tribes of Warm Springs, which have reservations in counties adjacent to Marion and Linn Counties, and the Cow Creek band of Umpqua Tribe of Indians, which have reservations in the county adjacent to Lane County, would be impacted the most. Members of the Confederated Tribe of Siletz Indians would experience fewer adverse impacts since they engage in cultural fishing activities at three sites in Lincoln County (namely Euchere Creek Falls, Drift Creek, and Little Rock Creek hatchery (CTSI No Date) that are located outside of the WVS. Similarly, the Confederated Tribes of Grand Ronde Community and the Umatilla Tribe would experience minimal adverse effects due to the long distance between their reservation and presumed tribal fishing sites and the project locations.

As described in Section 3.20.4.3.2, while the implementation of the proposed measures would not result in overall beneficial impacts to Tribal subsistence and ceremonial fishing activities, effects would be less adverse than those that are currently experienced by Tribes due to dwindling fish populations in the WRB. Overall, long-term adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would range from minor to moderate in magnitude and be large in extent. The continued existence of these fish species – or more precisely, their respective evolutionarily significant units (ESUs) and distinct population segments (DPSs) – in the WRB would support the preservation of Tribal cultural practices and the passing on of knowledge of traditional fishing methods and customs to their youth. These effects would be disproportionately high and adverse, but would not be significant.

#### *3.20.4.5.3 Climate Change*

As discussed in Section 3.20.4.4.3, climate change would adversely affect Tribal subsistence fishing, decreasing fish populations and therefore fish available for harvest. In particular, higher air and water temperatures, less water in river and reservoir systems, and more frequent and severe wildfires would decrease water quality from higher turbidity and increased occurrence of HABs (which would decrease dissolved oxygen (DO) concentrations and could adversely affect fish populations).

Under Alternative 1, adverse effects to Tribal subsistence fishing from construction/structural modification projects could be minor in the short and medium term and medium in extent. Climate change could exacerbate effects from construction/modification of structural measures, maintenance/rehabilitation projects, gravel augmentation, and revetment alteration, and the Fall Creek Drawdown, as increased wildfire ash, HABs, and erosion would further increase turbidity and could further reduce the quantity and quality of some fish species available for harvest. As such, the adverse effects of climate change and the measures under Alternative 1 would be minor to moderate in the short and medium term; and large in extent. These effects would be disproportionately high and adverse, but would not be significant.

Under Alternative 1, adverse effects to Tribal recreation would be major and adverse due to the Fall Creek drawdown. Climate change would further reduce water quantity with higher air and water temperatures and if there is less water in river and reservoir systems. Overall effects from climate change and the measures under the Alternative 1 would still be major in the short term and recur in the long term; and be small in extent. These disproportionately high and major, adverse effects would be considered significant.

Under Alternative 1, several structural and water management measures would be implemented, which would not result in overall beneficial impacts to Tribal subsistence and ceremonial fishing activities. However, effects would be less adverse than those that are currently experienced by Tribes; long-term adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would range from minor to moderate in magnitude and be large in extent. All of the climate change factors listed in Section 3.1.2.3 would work against the beneficial effects from implementing structural and water management measures under this alternative. As such, the effects of climate change combined with the measures under Alternative 1 would result in overall adverse effects that are moderate in magnitude, large in extent, and long-term. These effects would be disproportionately high and adverse, but would not be significant.

### *3.20.4.6 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 2A aims to improve fish passage through the WVS dams using a combination of modified operations and structural improvements, along with other measures to manage water management flexibility and meet ESA-listed fish obligations.

Construction/modification of structural measures:

- Gravel augmentation below dams (#384) would occur at CGR, BLU, FOS, and BCL;
- Maintenance or alteration of revetments (#9) would occur basin wide;
- Construction of water temperature control tower (#105) would occur at DET;
- Construction of adult fish facility (#722) would occur at GPR;
- Provision of Pacific lamprey passage and infrastructure (#52) would occur at GPR;
- Construction of structural downstream fish passage (#392) would occur at LOP, CGR, FOS, and DET; and
- Operation, Maintenance, Repair, Replacement and Rehabilitation would occur basin wide

Operation of structural measures and implementation of water management measures:

- Adaptation of Hatchery Program (#719) would occur at CGR, BLU, FOS, and BCL;
- Fish ladder temperature improvement (#479) would occur at FOS;
- Maintenance of existing and new fish release sites above dams (#726) would occur at LOP, FCR, HCR, CGR, FOS, GPR, BCL, and DET;
- Use of ROs to discharge colder water (#166) would occur at GPR;
- Augmentation of instream flows by using the inactive pool (#718) would occur at FCR and BLU;
- Augmentation of instream flows by using the power pool (#304) would occur at LOP, HCR, CGR, GPR, and DET;
- Use of integrated temperature and habitat flow regime (#30a) would occur basin wide
- Deeper fall reservoir drawdowns for fish passage (#40) would occur at GPR;
- Passage of water over spillway in spring for fish passage (#714) would occur at GPR;
- Fall Creek Drawdown would occur at FCR;
- Continued operation of existing AFFs at DEX, FCR, CGR, FOS, and BCL; and
- Near-term operations measures would occur at DET, BCL, GPR, FOS, CGR, HCR, LOP, and FCR

##### *3.20.4.6.1 Socioeconomic Effects; Noise Disturbance, Air Emissions, and Traffic*

The direct, indirect, and induced socioeconomic impacts to communities with EJ concerns due to the creation of construction jobs, impacts to the health of workers hired from communities with EJ concerns and communities with EJ concerns residing in the vicinity of the impacted reservoirs from air emissions and increased noise levels during construction/structural improvement activities, and traffic/transportation impacts during construction are described in Section 3.20.4.3.1.

Construction expenditures associated with Alternative 2A would total only approximately $1.1B, which is almost half of those which would occur under Alternative 1. Fewer construction and infrastructure improvement activities would be implemented compared to Alternative 1 and would impact fewer project locations. As a result, the magnitude of beneficial socioeconomic impacts to communities with EJ concerns, the adverse impacts to the health of construction workers from communities with EJ concerns and nearby residents of communities with EJ concerns due to construction-related emissions, noise generation, and traffic, and adverse impacts to tribal subsistence fishing activities and recreation under Alternative 2A would be less severe compared to Alternative 1.

As such, the direct and indirect socioeconomic impact of Alternative 2A on minority communities with EJ concerns would be beneficial, negligible to minor in magnitude, occur in the short term and medium term, and be medium in extent. Long-term beneficial impacts would be negligible in magnitude and medium in extent. Beneficial socioeconomic effects on communities with EJ concerns would be disproportionately high, but would not be significant. The magnitude of beneficial effects from activities proposed under Alternative 2A would be most severe for populations with EJ concerns in Marion County and relatively less severe for populations with EJ concerns in Washington County. Adverse impacts of construction and infrastructure improvement activities on the health of construction workers from communities with EJ concerns would occur in the short-term and medium-term and be negligible to minor in magnitude. The extent would be small and only affect workers at the project location. These effects would be disproportionately high and adverse, but would not be significant.

As discussed in 3.20.4.3.2, drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. The Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Cow Creek Band of Umpqua Tribe of Indians, and Confederated Tribes of the Umatilla Indian Reservation are not located in Lane and Linn counties, where the Fall Creek and Green Peter reservoirs (respectively) are located; and where annual drawdowns are proposed. However, as noted above, while many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022). As such, drawdowns could adversely and disproportionately affect tribal members throughout the WVS that are economically dependent on the Fall Creek and Green Peter reservoirs. Given that two annual drawdowns would occur at two reservoirs, the magnitude of effects would be minor and the extent would likely be medium under this alternative, occurring in some of the counties in the WVS. These effects would be disproportionately high and adverse, but would not be significant.

#### *3.20.4.6.2 Subsistence Fishing and Tribal Effects*

Impacts to subsistence fishing and recreation from construction activities; gravel augmentation and maintenance of revetments; and drawdowns at Green Peter and Fall Creek would vary across Tribes and would be determined by the distance between the Tribal fishing sites and the project locations, as described in Section 3.20.4.5.2 and 3.20.4.3. Under Alternative 2A, adverse effects would be minor, short-, medium-, and long-term recurring; and medium in extent. These effects would be disproportionately high and adverse, but would not be significant.

As discussed under in Section 3.20.4.3.2, drawdowns at Fall Creek and Green Peter would also have adverse and major effects to Tribal recreationists. Some recreationists would forego visitation to the reservoir altogether during the drawdowns. Others that continue to visit the reservoir during drawdowns would be adversely affected due to visual effects on the recreational experience. Effects would occur in the short term and recur in the long term. The extent of effects would be small because they would only occur at Fall Creek and Green Peter. These disproportionately high and major, adverse effects would be considered significant.

As described in Section 3.20.4.3.2, while the implementation of the proposed measures would not result in overall beneficial effects to Tribal subsistence and ceremonial fishing activities, effects would be less adverse than those that are currently experienced by Tribes due to dwindling fish populations in the WRB. Overall, long-term adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would range from minor to moderate in magnitude and be large in extent. The continued existence of these fish species – or more precisely, their respective evolutionarily significant units (ESUs) and distinct population segments (DPSs) – in the WRB would support the preservation of Tribal cultural practices and the passing on of knowledge of traditional fishing methods and customs to their youth. These effects would be disproportionately high and adverse, but would not be significant.

###### *3.20.4.6.3 Suite of Near-term Operations*

Near-term operations that could affect environmental justice include deep drawdowns and extended deep drawdowns, RO prioritization, and delayed reservoir refills for improved downstream fish passage. Similar to the effects discussed in Section 3.20.4.3.2 and 3.20.4.3.3, extended deep drawdowns and delayed reservoir refills would cause adverse effects to Tribal recreation and subsistence fishing activities downstream of reservoirs; and overall effects would still be minor, short-term and long-term recurring. These effects would be disproportionately high and adverse, but would not be significant. Under Alternative 2A, adverse effects to Tribal recreation would be major and adverse due to the Fall Creek and Green Peter drawdowns. Effects would still be major with the suite of near- term operations, small in extent, and short-term and long-term recurring. These disproportionately high and major, adverse effects would be considered significant. Overall, long-term adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would range from minor to moderate in magnitude and be large in extent.

###### *3.20.4.6.4 Climate Change*

As discussed in Section 3.20.4.4.3, climate change would adversely affect Tribal subsistence fishing, decreasing fish populations and therefore fish available for harvest. In particular, higher air and water temperatures, less water in river and reservoir systems, and more frequent and severe wildfires would decrease water quality from higher turbidity and increased occurrence of HABs (which would decrease dissolved oxygen (DO) concentrations and could adversely affect fish populations).

Under Alternative 2A, adverse effects to Tribal subsistence fishing could be minor in the short and medium term and medium in extent. Climate change could exacerbate effects from construction/modification of structural measures, maintenance/rehabilitation projects, gravel augmentation, revetment alteration, and drawdowns at Green Peter and Fall Creek, as increased wildfire ash, HABs, and erosion would further increase turbidity and could further reduce the quantity and quality of some fish species available for harvest. As such, the effects of climate change and the measures under Alternative 2A would be minor to moderate in the short and medium term; and large in extent. These effects would be disproportionately high and adverse, but would not be significant.

Under Alternative 2A, adverse effects to Tribal recreation would be major and adverse due to the drawdowns at Fall Creek and Green Peter. Climate change would further reduce water quantity with higher air and water temperatures and if there is less water in river and reservoir systems. Overall effects from climate change and the measures under the Alternative 2A would still be major in the short term and recur in the long term; and be small in extent. These disproportionately high and major, adverse effects would be considered significant.

Under Alternative 2A, a greater number of water management measures (compared to Alternative 1) would be implemented, which would not result in overall beneficial impacts to Tribal subsistence and ceremonial fishing activities. However, effects would be less adverse than those that are currently experienced by Tribes; long-term adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would range from minor to moderate in magnitude and be large in extent. All of the climate change factors listed in Section 3.1.2.3 would work against the beneficial effects from implementing several water management measures under this alternative. As such, the effects of climate change combined with the measures under Alternative 2A would result in overall adverse effects that are moderate in magnitude, large in extent, and long-term. These effects would be disproportionately high and adverse, but would not be significant.

#### *3.20.4.7 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 2B is similar to Alternative 2A but proposes a slightly different combination of measures at Cougar Dam that are $52M lower in construction expenditures than Alternative 2A. While Alternative 2A proposes constructing structural downstream fish passage at Cougar Dam, Alternative 2B includes changing operations at Cougar Dam by drafting the reservoir down so that fish can pass through the DT in the fall and spring. Under Alternative 2B, deep fall and spring drawdowns to the DT for fish passage would draft the reservoir below the power pool most of the time, making the power pool inaccessible for flow augmentation under Alternative 2B. Also, augmentation of instream flows by using the power pool (#304) would occur at four of the same locations but would not occur at Cougar Dam under Alternative 2B.

Given their overall similarity, the EJ effects of the measures under Alternative 2B are very similar to Alternative 2A and are affected by the same mechanisms discussed in Sections 3.20.4.3 and 3.20.4.6. Drawdown-related impacts would be slightly greater for Alternative 2B compared to Alternative 2A.

#### *3.20.4.7.1 Socioeconomic Effects; Noise Disturbance, Air Emissions, and Traffic*

The direct and indirect socioeconomic impact of Alternative 2B on minority communities with EJ concerns would be beneficial, negligible to minor in magnitude, occur in the short term and medium term, and be medium in extent. Long-term beneficial impacts would be negligible in magnitude and medium in extent. Beneficial socioeconomic effects on communities with EJ concerns would be disproportionately high, but would not be significant. The magnitude of beneficial effects from activities proposed under Alternative 2B would be most pronounced for populations with EJ concerns in Marion County and relatively less intense for populations with EJ concerns in Washington County. Adverse impacts of construction and infrastructure improvement activities on the health of construction workers from communities with EJ concerns would occur in the short term and medium term and be negligible to minor in magnitude. Effects to minority communities with EJ concerns would be the same as those under Alternative 2A. Effects would be small in extent and only affect workers at the project location. These effects would be disproportionately high and adverse, but would not be significant.

As discussed in 3.20.4.3.2, drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. The Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Cow Creek Band of Umpqua Tribe of Indians, and Confederated Tribes of the Umatilla Indian Reservation are not located in Lane and Linn counties, where the Fall Creek, Green Peter, and Cougar reservoirs are located – and where annual drawdowns are proposed. However, as noted above, while many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022). As such, drawdowns could adversely and disproportionately affect tribal members throughout the WVS that are economically dependent on the Fall Creek, Green Peter, and Cougar reservoirs. Given that three annual drawdowns would occur at three reservoirs, the magnitude of effects would be moderate and the extent would likely be medium under this alternative, occurring in some of the counties in the WVS. These effects would be disproportionately high and adverse, but would not be significant.

#### *3.20.4.7.2 Subsistence Fishing and Tribal Effects*

Impacts to subsistence fishing and recreation from construction activities; gravel augmentation and maintenance of revetments; and drawdowns at Green Peter, Fall Creek, and Cougar would vary across Tribes and would be determined by the distance of the Tribal fishing sites from the project locations, as described in Section 3.20.4.5.2 and 3.20.4.3. As such, these adverse effects would be minor in magnitude; short-, medium-, and long-term recurring in duration; and medium in extent. These effects would be disproportionately high and adverse, but would not be significant.

As discussed under in Section 3.20.4.3.2, drawdowns at Cougar, Fall Creek, and Green Peter would also have adverse and major effects to Tribal recreationists. Some recreationists would forego visitation to the reservoir altogether during the drawdowns. Others that continue to visit the reservoir during drawdowns would be adversely affected due to visual effects on the recreational experience. Effects would occur in the short term and recur in the long term. The extent of effects would be small because they would only occur at Cougar, Fall Creek, and Green Peter. These disproportionately high and major, adverse effects would be considered significant.

EJ impacts of the measures under Alternative 2B are very similar to Alternative 2A and are affected by the same mechanisms discussed in Sections 3.20.4.3 and 3.20.4.6.2. While the implementation of the proposed measures would not result in overall beneficial effects to Tribal subsistence and ceremonial fishing activities, effects would be less adverse than those that are currently experienced by Tribes due to dwindling fish populations in the WRB. Overall, long-term adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would range from minor to moderate in magnitude and be large in extent. The continued existence of these fish species – or more precisely, their respective evolutionarily significant units (ESUs) and distinct population segments (DPSs) – in the WRB would support the preservation of Tribal cultural practices and the passing on of knowledge of traditional fishing methods and customs to their youth. These effects would be disproportionately high and adverse, but would not be significant.

#### *3.20.4.7.3 Suite of Near-term Operations*

The implementation of near-term operations would also cause adverse impacts to Tribal subsistence fishing activities downstream of reservoirs; but overall effects would still be minor, short-term and long-term recurring. These effects would be disproportionately high and adverse, but would not be significant. Under Alternative 2B, adverse effects to Tribal recreation would be major and adverse due to the drawdowns at Cougar, Fall Creek, and Green Peter. Effects would still be major with the suite of near- term operations, small in extent, and short term and long-term recurring. These disproportionately high and major, adverse effects would be considered significant. Overall, long-term adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would range from minor to moderate in magnitude and be large in extent.

#### *3.20.4.7.4 Climate Change*

The effects of climate change and the measures under Alternative 2B would be the same as those under Alternative 2A and are described in Section 3.20.4.6.4. The differences between alternatives 2A and 2B, like constructing a downstream fish passage at Cougar under Alternative 2A instead of a drawdown under Alternative 2B, would not change the analysis or affect the conclusions. The effects of climate change and the measures under Alternative 2A on

Tribal subsistence fishing would be minor to moderate in the short and medium term; and large in extent. These effects would be disproportionately high and adverse, but would not be significant. Overall effects from climate change and the measures under the Alternative 2A to Tribal recreation would still be major in the short term and recur in the long term; and be small in extent. These disproportionately high and major, adverse effects would be considered significant. The long-term effects of climate change combined with the measures under Alternative 2A to Tribal subsistence and ceremonial fishing activities would result in overall adverse effects that are moderate in magnitude, large in extent, and long-term. These effects would be disproportionately high and adverse, but would not be significant.

#### *3.20.4.8 Alternative 3A – Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)*

Alternative 3A focuses on modifying operations rather than storage or structural measures to improve the survival of ESA-listed fish species. Operational measures in Alternative 3A are intended to improve downstream fish passage, increase water management flexibility, optimize conservation season draft rates, and reduce impaired water quality below the WVS dams to benefit ESA-listed fish species.

Construction/modification of structural measures:

- Gravel augmentation below dams (#384) would occur at CGR, BLU, FOS, and DET;
- Maintenance or alteration of revetments (#9) would occur basin wide;
- Construction of adult fish facility (#722) would occur at HCR, BLU, and GPR;
- Provision of Pacific lamprey passage and infrastructure (#52) would occur at HCR, BLU, and GPR; and
- Operation, Maintenance, Repair, Replacement and Rehabilitation would occur basin wide

Operation of structural measures and implementation of water management measures:

- Adaptation of Hatchery Program (#719) would occur at DEX, LOP, FCR, HCR, CGR, BLU, FOS, GPR, BCL, and DET;
- Maintenance of existing and new fish release sites above dams (#726) would occur basin-wide;
- Use of Ros to discharge colder water (#166) would occur at LOP, GPR, and DET;
- Augmentation of instream flows by using the inactive pool (#718) would occur at CTG, DOR, FCR, and BLU;
- Augmentation of instream flows by using the power pool (#304) would occur at LOP, HCR, CGR, GPR, and DET;
- Use of integrated temperature and habitat flow regime (#30a) would occur basin wide;

- Deeper fall reservoir drawdowns for fish passage (#40) would occur at LOP, HCR, CGR, BLU, GPR, and DET;
- Spring reservoir drawdown for downstream fish passage (#720) would occur at LOP, CGR, and DET;
- Passage of water over spillway in spring for fish passage (#714) would occur at DEX, FCR, HCR, BCL, and GPR;
- Fall Creek Drawdown would occur at FCR;
- Continued operation of existing AFFs at DEX, FCR, CGR, FOS, and BCL; and
- Near-term operations measures would occur at LOP, DET, BCL, GPR, FOS, CGR, HCR, and FCR

##### *3.20.4.8.1 Socioeconomic Effects; Noise Disturbance, Air Emissions, and Traffic*

Alternative 3A would result in the implementation of fewer construction and infrastructure improvement activities compared to all other alternatives. As a result, the beneficial socioeconomic impacts to communities with EJ concerns and the adverse impacts to the health of these communities due to construction-related emissions, noise generation, and increased traffic would be less pronounced compared to all other alternatives.

Construction expenditures associated with Alternative 3A would total only approximately $330M, which is only 34 percent of those of Alternatives 2A and 2B. As such (and as described in Section 3.20.4.3.1), the direct and indirect socioeconomic impact of Alternative 3A on minority communities with EJ concerns would be beneficial, negligible in magnitude, occur in the short term and medium term, and be medium in extent. Long-term beneficial impacts would be negligible in magnitude and medium in extent. Beneficial socioeconomic effects on communities with EJ concerns would be disproportionately high, but would not be significant. Beneficial effects from activities proposed under Alternative 3A would be most pronounced for populations with EJ concerns in Marion County and relatively less intense for populations with EJ concerns in Washington County. Adverse effects of construction and infrastructure improvement activities on the health of construction workers hired from communities with EJ concerns to work at the project locations would occur in the short term and medium term and be negligible in magnitude. Effects would be small in extent and only affect workers at the project location. These effects would be disproportionately high and adverse, but would not be significant.

As discussed in 3.20.4.3.2, drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. Minority populations with EJ concerns in Marion County could experience disproportionate and adverse effects associated with the fall and spring drawdowns at Detroit Reservoir. As described in 3.20.3, the Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Cow Creek Band of Umpqua Tribe of Indians, and Confederated Tribes of the Umatilla Indian Reservation are located in Yamhill, Jefferson and Wasco, Wasco, Lincoln, and

Lincoln counties (respectively). Drawdowns are not proposed at any of the reservoirs located in the aforementioned counties. However, as noted above, while many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022). As such, drawdowns could adversely and disproportionately affect tribal members throughout the WVS that are economically dependent on the seven reservoirs where drawdowns are proposed. Given that a total of ten drawdowns would occur at seven reservoirs, the magnitude of effects would be major and the extent would likely be large under this alternative, occurring in all the counties in the WVS. These disproportionately high and major, adverse effects would be considered significant.

#### *3.20.4.8.2 Subsistence Fishing and Tribal Effects*

Impacts to subsistence and recreational fishing from construction activities; gravel augmentation and maintenance of revetments; and drawdowns at Green Peter, Fall Creek, Cougar, Lookout Point, Hills Creek, Blue River and Detroit would vary across Tribes and would be determined by the distance of the Tribal fishing sites from the project locations, as described in Section 3.20.4.3.2. Effects from reservoir drawdowns would be more pronounced under Alternative 3A compared to all other alternatives since the total number of drawdowns would be higher and would occur at far more reservoirs. As such, these adverse impacts would be minor to moderate, short-, medium-, and long-term recurring; and medium in extent. These effects would be disproportionately high and adverse, but would not be significant.

As discussed under in Section 3.20.4.3.2, drawdowns at Green Peter, Fall Creek, Cougar, Lookout Point, Hills Creek, Blue River and Detroit would have adverse and major effects to Tribal recreationists. Some recreationists would forego visitation to the reservoir altogether during the drawdowns. Others that continue to visit the reservoir during drawdowns would be adversely affected due to visual effects on the recreational experience. Effects would occur in the short term and recur in the long term. The extent of effects would be small because they would only occur at the reservoirs themselves. These disproportionately high and major, adverse effects would be considered significant.

Alternative 3A would implement a greater number and variety of water management measures to improve fish passage. As described in Section 3.20.4.3.2, while the implementation of the proposed measures would not result in overall beneficial effects to Tribal subsistence and ceremonial fishing activities, effects would be less adverse than those that are currently experienced by Tribes due to dwindling fish populations in the WRB. Effects under Alternative 3A (and 3B) would be the least adverse compared to the other alternatives, and overall, long-term adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would be minor in magnitude and large in extent. The continued existence of these fish species – or more precisely, their respective evolutionarily significant units (ESUs) and distinct population segments (DPSs) – in the WRB would support the preservation of Tribal cultural practices and the passing on of knowledge of traditional fishing methods and customs to their youth. These effects would be disproportionately high and adverse, but would not be significant.

#### *3.20.4.8.3 Suite of Near-term Operations*

The implementation of near-term operations would also cause adverse impacts to Tribal subsistence fishing activities downstream of reservoirs; but overall effects would still be minor, short-term and long-term recurring. These effects would be disproportionately high and adverse, but would not be significant. Under Alternative 3A, adverse effects to Tribal recreation would be major and adverse due to the drawdowns at Green Peter, Fall Creek, Cougar, Lookout Point, Hills Creek, Blue River and Detroit. Effects would still be major with the suite of near-term operations, small in extent, and short term and long-term recurring. These disproportionately high and major, adverse effects would be considered significant. Overall, long-term adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would be minor in magnitude and large in extent due to the greater number and variety of water management measures to improve fish passage.

#### *3.20.4.8.4 Climate Change*

As discussed in Section 3.20.4.4.3, climate change would adversely affect Tribal subsistence fishing, decreasing fish populations and therefore fish available for harvest. In particular, higher air and water temperatures, less water in river and reservoir systems, and more frequent and severe wildfires would decrease water quality from higher turbidity and increased occurrence of HABs (which would decrease dissolved oxygen (DO) concentrations and could adversely affect fish populations).

Under Alternative 3A, adverse effects to Tribal subsistence fishing could be minor to moderate in the short and medium term and medium in extent. Climate change could exacerbate effects from construction/modification of structural measures, maintenance/rehabilitation projects, gravel augmentation, revetment alteration, and drawdowns at Green Peter, Fall Creek, Cougar, Lookout Point, Hills Creek, Blue River and Detroit, as increased wildfire ash, HABs, and erosion would further increase turbidity and could further reduce the quantity and quality of some fish species available for harvest. As such, the effects of climate change and the measures under Alternative 3A would be moderate in the short and medium term and large in extent. These effects would be disproportionately high and adverse, but would not be significant.

Under Alternative 3A, adverse effects to Tribal recreation would be major and adverse due to the drawdowns at Green Peter, Fall Creek, Cougar, Lookout Point, Hills Creek, Blue River and Detroit. Climate change would further reduce water quantity with higher air and water temperatures and if there is less water in river and reservoir systems. Overall effects from climate change and the measures under the Alternative 3A would still be major in the short term and recur in the long term; and be small in extent. These disproportionately high and major, adverse effects would be considered significant.

Under Alternative 3A, several water management measures would be implemented to increase the availability of fish species to subsistence communities with EJ concerns, which would not result in overall beneficial impacts to Tribal subsistence and ceremonial fishing activities. However, effects would be less adverse than those that are currently experienced by Tribes (3A and 3B would be the least adverse due to the number of drawdowns); long-term adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would be minor in magnitude and large in extent. All of the climate change factors listed in Section 3.1.2.3 would work against the beneficial effects from implementing several water management measures under this alternative. As such, the effects of climate change combined with the measures under Alternative 3A would result in overall adverse effects that are minor to moderate in magnitude, large in extent, and long-term. These effects would be disproportionately high and adverse, but would not be significant.

#### *3.20.4.9 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at COU)*

Alternative 3B is similar to Alternative 3A but differs primarily by their downstream passage measures. Alternative 3A proposes downstream fish passage elements at a different combination of projects and includes drawdown drafting to 10 feet over the top of the Cougar Dam RO for deep fall and spring drawdown measures. Alternative 3B, diversely, includes drawdown drafting to the DT at Cougar for both drawdown measures, a much deeper drawdown than proposed under Alternative 3A. Also, under Alternative 3B, the integrated temperature and habitat flow regime (Measure #30a as described in Section 2.3.1.1) would only be utilized at LOP, HCR, GPR, and DET, as opposed to Alternative 3A which includes all dams in the WVS. Given their overall similarity, the EJ impacts of the measures under Alternative 3B are very similar to Alternative 3A and are affected by the same mechanisms discussed in Section 3.20.2.3.

##### *3.20.4.9.1 Socioeconomic Effects; Noise Disturbance, Air Emissions, and Traffic*

Construction expenditures associated with Alternative 3B would total approximately $415M, or $85M in additional construction and maintenance expenditures of Alternative 3B. The direct and indirect socioeconomic impact of Alternative 3B on minority communities with EJ concerns would be beneficial, negligible in magnitude, occur in the short term and medium term, and be medium in extent. Long-term beneficial impacts would be negligible in magnitude and medium in extent. Beneficial socioeconomic effects on communities with EJ concerns would be disproportionately high, but would not be significant. Beneficial effects from activities proposed under Alternative 3B would be most pronounced for populations with EJ concerns in Marion County and relatively less intense for populations with EJ concerns in Washington County. Adverse impacts of construction and infrastructure improvement activities on the health of communities with EJ concerns hired to work on the project would occur in the short term and medium term and be negligible in magnitude. Effects would be small in extent and only affect workers at the project location. These effects would be disproportionately high and adverse, but would not be significant.

As discussed in 3.20.4.3.2, drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. Minority populations with EJ concerns in Marion County could experience disproportionate and adverse effects associated with the fall and spring drawdowns at Detroit Reservoir. As described in 3.20.3, the Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Cow Creek Band of Umpqua Tribe of Indians, and Confederated Tribes of the Umatilla Indian Reservation are located in Yamhill, Jefferson and Wasco, Wasco, Lincoln, and Lincoln counties (respectively). Drawdowns are not proposed at any of the reservoirs located in the aforementioned counties. However, as noted above, while many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022). As such, drawdowns could adversely and disproportionately affect tribal members throughout the WVS that are economically dependent on the seven reservoirs where drawdowns are proposed. Given that a total of ten drawdowns would occur at seven reservoirs, the magnitude of effects would be major and the extent would likely be large under this alternative, occurring in all the counties in the WVS. These disproportionately high and major, adverse effects would be considered significant.

###### *3.20.4.9.2 Subsistence Fishing and Tribal Effects*

Impacts to subsistence and recreational fishing from construction activities; gravel augmentation and maintenance of revetments; and drawdowns at Green Peter, Fall Creek, Cougar, Lookout Point, Hills Creek, Blue River and Detroit would vary across Tribes and would be determined by the distance of the Tribal fishing sites from the project locations, as described in Section 3.20.4.3.2. Similar to Alternative 3A, effects from reservoir drawdowns would be more pronounced under this alternative compared to alternatives 1, 2A, and 2B since the total number of drawdowns would be higher and would occur at far more reservoirs. As such, adverse effects would be minor to moderate-, short-, medium-, and long-term recurring and medium in extent. These effects would be disproportionately high and adverse, but would not be significant.

As discussed under in Section 3.20.4.3.2, drawdowns at Green Peter, Fall Creek, Cougar, Lookout Point, Hills Creek, Blue River and Detroit would have adverse and major effects to Tribal recreationists. Some recreationists would forego visitation to the reservoir altogether during the drawdowns. Others that continue to visit the reservoir during drawdowns would be adversely affected due to visual effects on the recreational experience. Effects would occur in the short term and recur in the long term. The extent of effects would be small because they would only occur at the reservoirs themselves. These disproportionately high and major, adverse effects would be considered significant.

Like Alternative 3A, Alternative 3B would implement a greater number and variety of water management measures to improve fish passage. As described in Section 3.20.4.3.2, while the implementation of the proposed measures would not result in overall beneficial effects to Tribal subsistence and ceremonial fishing activities, effects would be less adverse than those that are currently experienced by Tribes due to dwindling fish populations in the WRB. Effects under Alternative 3B (and 3A) would be the least adverse compared to the other alternatives, and overall, long-term adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would be minor in magnitude and large in extent. The continued existence of these fish species – or more precisely, their respective evolutionarily significant units (ESUs) and distinct population segments (DPSs) – in the WRB would support the preservation of Tribal cultural practices and the passing on of knowledge of traditional fishing methods and customs to their youth. These effects would be disproportionately high and adverse, but would not be significant.

##### *3.20.4.9.3 Suite of Near-term Operations*

The implementation of near-term operations would also cause adverse impacts to Tribal subsistence fishing activities downstream of reservoirs; but overall effects would still be minor, short-term and long-term recurring. These effects would be disproportionately high and adverse, but would not be significant. Under Alternative 3B, adverse effects to Tribal recreation would be major and adverse due to the drawdowns at Green Peter, Fall Creek, Cougar, Lookout Point, Hills Creek, Blue River and Detroit. Effects would still be major with the suite of near-term operations, small in extent, and short-term and long-term recurring. These disproportionately high and major, adverse effects would be considered significant. Overall, long-term adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would be minor in magnitude and large in extent due to the greater number and variety of water management measures to improve fish passage.

##### *3.20.4.9.4 Climate Change*

The effects of climate change and the measures under Alternative 3B would be the same as those under Alternative 3A and are described in Section 3.20.4.8.4. The differences between alternatives 3A and 3B – like a much deeper drawdown at Cougar under Alternative 3B compared to 3A – would not change the analysis or affect the conclusions. The effects of climate change and the measures under Alternative 3B on Tribal subsistence fishing would be moderate in the short and medium term and large in extent. These effects would be disproportionately high and adverse, but would not be significant. Overall effects from climate change and the measures under the Alternative 3A on Tribal recreation would be major in the short term and recur in the long term; and be small in extent. These disproportionately high and major, adverse effects would be considered significant. Effects of climate change combined with the measures under Alternative 3A to Tribal subsistence and ceremonial fishing activities would result in overall adverse effects that are minor to moderate in magnitude, large in extent, and long-term. These effects would be disproportionately high and adverse, but would not be significant.

#### ***3.20.4.10 Alternative 4 – Structures-Based Fish Passage Alternative***

Alternative 4 consists almost entirely of structural improvements which increase stream flows and enhance fish passage in support of improved survival of ESA-listed fish species.

Construction/modification of structural measures:

- Gravel augmentation below dams (#384) would occur at CGR, BLU, FOS, and BCL;

- Maintenance or alteration of revetments (#9) would occur basin wide;
- Construction of water temperature control tower (#105) would occur at LOP, HCR, and DET;
- Structural improvements to reduce TDG (#174) would occur at DEX, LOP, CGR, FOS, GPR, and DET;
- Restoration of upstream and downstream passage at drop structures (#639) would occur at FRN;
- Construction of adult fish facility (#722) would occur at HCR;
- Provision of Pacific lamprey passage and infrastructure (#52) would occur at FRN and GPR;
- Construction of structural downstream fish passage (#392) would occur at LOP, FOS, GPR, and DET; and
- Operation, Maintenance, Repair, Replacement and Rehabilitation would occur basin wide

Operation of structural measures and implementation of water management measures:

- Adaptation of Hatchery Program (#719) would occur at DEX, LOP, FCR, HCR, CGR, BLU, FOS, GPR, BCL, and DET;
- Fish ladder temperature improvement (#479) would occur at FOS;
- Maintenance of existing and new fish release sites above dams (#726) would occur at LOP, FCR, HCR, CGR, FOS, GPR, BCL, and DET;
- Use of ROs to discharge colder water (#166) would occur at GPR;
- Augmentation of instream flows by using the inactive pool (#718) would occur at FCR and BLU;
- Augmentation of instream flows by using the power pool (#304) would occur at LOP, HCR, GPR, and DET;
- Use of integrated temperature and habitat flow regime (#30a) would occur basin wide
- Deeper fall reservoir drawdowns for fish passage (#40) would occur at CGR and GPR;
- Spring reservoir drawdown for downstream fish passage (#720) would occur at CGR;
- Passage of water over spillway in spring for fish passage (#714) would occur at GPR;
- Fall Creek Drawdown would occur at FCR;
- Continued operation of existing AFFs would occur at DEX, FCR, CGR, FOS, and BCL; and
- Near-term operations measures would occur at DET, BCL, GPR, FOS, CGR, HCR, and FCR

Under Alternative 4, effects would be similar in nature to the impacts described in Section 3.20.4.3.1.

#### *3.20.4.10.1 Socioeconomic Effects; Noise Disturbance, Air Emissions, and Traffic*

The construction-related impacts under this alternative would be similar to the impacts expected under Alternative 1, though they may occur at different project locations compared to Alternative 1. The magnitude of such impacts would be greater compared to Alternatives 2A, 2B, 3A, and 3B.

Construction and maintenance expenditures associated with Alternative 4 would total approximately $2.0B, which is $200M greater than those of Alternative 1, and the most expensive of the alternatives. As such, the direct and indirect socioeconomic effect of Alternative 4 on minority communities with EJ concerns would be beneficial, minor in magnitude, occur in the short term and medium term, and be medium in extent. Long-term beneficial effects would be negligible in magnitude and medium in extent. Beneficial socioeconomic effects on communities with EJ concerns would be disproportionately high, but would not be significant. Effects from activities proposed under Alternative 4 would be most pronounced for populations with EJ concerns in Marion County and relatively less intense for populations with EJ concerns in Washington County. Adverse effects of construction and infrastructure improvement activities on the health of construction workers would occur in the short term and medium term and be minor in magnitude. Effects would be small in extent and only affect workers at the project location. These effects would be disproportionately high and adverse, but would not be significant.

As discussed in 3.20.4.3.2, drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. The Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Cow Creek Band of Umpqua Tribe of Indians, and Confederated Tribes of the Umatilla Indian Reservation are not located in Lane County, where the Fall Creek Drawdown occurs. However, as noted above, while many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022). As such, drawdowns could adversely and disproportionately affect tribal members throughout the WVS that are economically dependent on the Fall Creek Reservoir. Given that one drawdown would occur annually in one county, the magnitude of effects would be minor and the extent would likely be medium under this alternative, occurring in some of the counties in the WVS. These effects would be disproportionately high and adverse, but would not be significant.

#### *3.20.4.10.2 Subsistence Fishing and Tribal Effects*

Impacts to subsistence and recreational fishing from construction activities; major maintenance and rehabilitation projects; gravel augmentation and maintenance of revetments; and reservoir drawdowns would vary across Tribes and would be determined by the distance of the Tribal fishing sites from the project locations, as described in Section 3.20.4.3. As such, these adverse impacts would be minor in magnitude, short-, medium-, and long-term recurring, and medium in extent. These effects would be disproportionately high and adverse, but would not be significant. The severity of drawdown-related impacts would be the same as Alternative 1 and the NAA and would only occur at Fall Creek.

As discussed under in Section 3.20.4.3.2 and the NAA, the Fall Creek drawdown would have adverse and major effects to Tribal recreationists. Some recreationists would forego visitation to the reservoir altogether during the drawdowns. Others that continue to visit the reservoir during drawdowns would be adversely affected due to visual effects on the recreational experience. Effects would occur in the short term and recur in the long term. The extent of effects would be small because they would only occur at Fall Creek. These disproportionately high and major, adverse effects would be considered significant.

As described in Section 3.20.4.3.2, while the implementation of the proposed measures would not result in overall beneficial impacts to Tribal subsistence and ceremonial fishing activities, effects would be less adverse than those that are currently experienced by Tribes due to dwindling fish populations in the WRB. Overall, long-term adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would range from minor to moderate in magnitude and be large in extent. The continued existence of these fish species – or more precisely, their respective evolutionarily significant units (ESUs) and distinct population segments (DPSs) – in the WRB would support the preservation of Tribal cultural practices and the passing on of knowledge of traditional fishing methods and customs to their youth. These effects would be disproportionately high and adverse, but would not be significant.

#### *3.20.4.10.3 Suite of Near-term Operations*

The implementation of near-term operations would also cause adverse impacts to Tribal subsistence fishing activities downstream of reservoirs; but overall effects would still be minor, short-term and long-term recurring. These effects would be disproportionately high and adverse, but would not be significant. Under Alternative 4, adverse effects to Tribal recreation would be major and adverse due to the Fall Creek drawdown. Effects would still be major with the suite of near- term operations, small in extent, and short term and long-term recurring. These disproportionately high and major, adverse effects would be considered significant. Overall, long-term adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would range from minor to moderate in magnitude and be large in extent.

#### *3.20.4.10.4 Climate Change*

The effects of climate change and the measures under Alternative 4 would be similar to those under Alternatives 1 and 2B and are described in Section 3.20.4.5.3 and 3.20.4.7.4. Overall effects from climate change and the measures under the Alternative 4 on Tribal recreation would be major in the short term and recur in the long term; and be small in extent. These disproportionately high and major, adverse effects would be considered significant. The effects of climate change combined with the measures under Alternative 4 on Tribal subsistence and ceremonial fishing activities would result in overall adverse effects that are moderate in magnitude, large in extent, and long-term. These effects would be disproportionately high and adverse, but would not be significant.

### *3.20.4.11 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 5 only differs from Alternative 2B by way of the refined integrated temperature management and habitat flow regime measure (#30b), which is not a measure that would change the effects determination. Therefore, the effects of Alternative 5 would be identical to those of Alternative 2B.

#### *3.20.4.11.1 Socioeconomic Effects; Noise Disturbance, Air Emissions, and Traffic*

The direct and indirect socioeconomic effect of Alternative 5 on minority communities with EJ concerns would be beneficial, negligible to minor in magnitude, occur in the short term and medium term, and be medium in extent. Long-term beneficial impacts would be negligible in magnitude and medium in extent. Beneficial socioeconomic effects on communities with EJ concerns would be disproportionately high, but would not be significant. The magnitude of beneficial effects from activities proposed under Alternative 5 would be most pronounced for populations with EJ concerns in Marion County and relatively less intense for populations with EJ concerns in Washington County. Adverse impacts of construction and infrastructure improvement activities on the health of construction workers from communities with EJ concerns would occur in the short term and medium term and be negligible to minor in magnitude. The extent of effects would be small and only affect workers at the project location. These effects would be disproportionately high and adverse, but would not be significant.

As discussed in 3.20.4.3.2, drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. The Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Cow Creek Band of Umpqua Tribe of Indians, and Confederated Tribes of the Umatilla Indian Reservation are not located in Lane and Linn counties, where the Fall Creek, Green Peter, and Cougar reservoirs are located – and where annual drawdowns are proposed. However, as noted above, while many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022). As such, drawdowns could adversely and disproportionately affect tribal members throughout the WVS that are economically dependent on the Fall Creek, Green Peter, and Cougar reservoirs. Given that three annual drawdowns would occur at three reservoirs, the magnitude of effects would be moderate and the extent would likely be medium under this alternative, occurring in some of the counties in the WVS. These effects would be disproportionately high and adverse, but would not be significant.

#### *3.20.4.11.2 Subsistence Fishing and Tribal Effects*

Impacts to subsistence and recreational fishing from construction activities; gravel augmentation and maintenance of revetments; and drawdowns at Green Peter, Fall Creek, and Cougar would vary across Tribes and would be determined by the distance of the Tribal fishing sites from the project locations, as described in Section 3.20.4.3 and 3.20.4.5.2. As such, these adverse impacts would be minor; short-, medium-, and long-term recurring; and medium in extent. These effects would be disproportionately high and adverse, but would not be significant.

As discussed under in Section 3.20.4.3.2, drawdowns at Cougar, Fall Creek, and Green Peter would also have adverse and major effects to Tribal recreationists. Some recreationists would forego visitation to the reservoir altogether during the drawdowns. Others that continue to visit the reservoir during drawdowns would be adversely affected due to visual effects on the recreational experience. Effects would occur in the short term and recur in the long term. The extent of effects would be small because they would only occur at Cougar, Fall Creek, and Green Peter. These disproportionately high and major, adverse effects would be considered significant.

EJ impacts of the measures under Alternative 5 are the same as Alternative 2B and are affected by the same mechanisms discussed in Sections 3.20.4.3 and 3.20.4.6.2. While the implementation of the proposed measures would not result in overall beneficial effects to Tribal subsistence and ceremonial fishing activities, effects would be less adverse than those that are currently experienced by Tribes due to dwindling fish populations in the WRB. Overall, long-term adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would range from minor to moderate in magnitude and be large in extent. The continued existence of these fish species – or more precisely, their respective evolutionarily significant units (ESUs) and distinct population segments (DPSs) – in the WRB would support the preservation of Tribal cultural practices and the passing on of knowledge of traditional fishing methods and customs to their youth. These effects would be disproportionately high and adverse, but would not be significant.

#### *3.20.4.11.3 Suite of Near-term Operations*

The implementation of near-term operations would also cause adverse impacts to Tribal subsistence fishing activities downstream of reservoirs; but overall effects would still be minor, short-term and long-term recurring. These effects would be disproportionately high and adverse, but would not be significant. Under Alternative 5, adverse effects to Tribal recreation would be major and adverse due to the drawdowns at Cougar, Fall Creek, and Green Peter. Effects would still be major with the suite of near-term operations, small in extent, and short-term and long-term recurring. These disproportionately high and major, adverse effects would be considered significant. Overall, long-term adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would range from minor to moderate in magnitude and be large in extent.

#### *3.20.4.11.4 Climate Change*

The effects of climate change and the measures under Alternative 5 would be the same as those under Alternative 2B. The effects of climate change and the measures under Alternative 2B/5 on Tribal subsistence fishing would be minor to moderate in the short and medium term;

and large in extent. These effects would be disproportionately high and adverse, but would not be significant. Overall effects from climate change and the measures under the Alternative 2B/5 to Tribal recreation would still be major in the short term and recur in the long term; and be small in extent. These disproportionately high and major, adverse effects would be considered significant. The long-term effects of climate change combined with the measures under Alternative 2A to Tribal subsistence and ceremonial fishing activities would result in overall adverse effects that are moderate in magnitude, large in extent, and long-term. These effects would be disproportionately high and adverse, but would not be significant.

#### *3.20.4.12 Conclusion*

The socioeconomic and health impacts from construction and structural improvement measures on communities with EJ concerns, including Tribes, would be most severe for Alternatives 1 and 4, and least severe for alternatives 3A and 3B since the greatest number of construction/structural measures would be implemented under Alternatives 1 and 4.

Conversely, effects from the implementation of water management measures, including reservoir drawdowns, would be most severe for Alternatives 3A and 3B, followed by Alternative 2A, 2B/5, and least severe for Alternatives 1 and 4. Major and adverse effects to Tribal recreation would occur under all alternatives due to drawdowns. These disproportionately high and major, adverse effects would be considered significant under all alternatives.

While the implementation of the proposed measures under any of the alternatives would not result in overall beneficial impacts to Tribal subsistence and ceremonial fishing activities, effects would be less adverse than those that are currently experienced by Tribes due to dwindling fish populations in the WRB. Overall, long-term adverse effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would range from minor to moderate in magnitude and be large in extent; and be the least adverse under Alternatives 3A and 3B. The continued existence of these fish species – or more precisely, their respective evolutionarily significant units (ESUs) and distinct population segments (DPSs) – in the WRB would support the preservation of Tribal cultural practices and the passing on of knowledge of traditional fishing methods and customs to their youth. These effects would be disproportionately high and adverse, but would not be significant.

## 3.21 CULTURAL RESOURCES

The term *cultural resources* refers to the physical manifestations that represent the heritage of a place and are associated with peoples who have historic connections to that place. For the purposes of this Draft PEIS, cultural resources include pre-contact and historical archaeological objects, features, and deposits located above or below the ground surface that are tangible evidence of prior human occupation or use in a particular area, architecture or elements of the built environment, and places or landscapes that a group of people consider culturally important because of events or practices that have occurred at the location. The last category includes places known as traditional cultural properties (TCPs) or historic properties of religious and cultural significance to Indian tribes (HPRCSITs).

Section 106 of the National Historic Preservation Act (NHPA), as amended, and the Act's implementing regulations *Protection of Historic Properties*, 36 CFR Part 800, requires the Corps to identify, evaluate for significance and potential listing in the National Register of Historic Places, and mitigate adverse effects to cultural resources that are identified as *historic properties* see Chapter 7. Historic properties are typically, but not always, at least 50 years old and retain integrity related to location, design, setting, materials, workmanship, feeling, or association. Historic properties must also be associated with significant historical events or people, represent a distinctive style of construction, retain stylistic elements representative of a master artisan, or be likely to provide important information about the past through continued study.

For the WVS 13 multipurpose dam and reservoir project areas located in Benton, Lane, Linn, and Marion counties, the Corps utilizes a program-level programmatic agreement (PA) to comply with Section 106 of the NHPA. This document modifies the Section 106 process to follow a streamlined and standardized approach to manage cultural resources that have the potential to be impacted by Corps' undertakings related to the current and future operations of the WVS. This applies to large scale operational measures as well as site-specific actions and structural measures that would be assessed through the tiered NEPA approach. The PA document was executed recently, on June 7, 2022, in partnership with several federal, state, and tribal partners and other interested parties. Per Stipulation VII (Historic Property Management Plan) of the PA, the Corps and partners are developing a companion document to the PA, known as a historic property management plan, that would allow for streamlined management and protection of historic properties that would be affected by the operations and maintenance of the WVS. For any actions that would occur as part of the PEIS, and are not covered in the PA, the Corps would utilize 36 CFR Part 800 to comply with the NHPA.

The Corps is also required to protect any archaeological resources that are at least 100 years of age from vandalism and illicit collection by complying with the Archaeological Resources Protection Act (ARPA). The Native American Graves Protection and Repatriation Act (NAGPRA) also directs the Corps to identify and protect Native American human remains, funerary objects, sacred objects, and objects of cultural patrimony of any age that are under federal management and return them to lineal descendants. Corps Engineering Regulations 1130-2-540

*Cultural Resources Management* provides guidance for how the Agency complies with ARPA, NAGPRA, and NHPA.

The area of analysis for cultural resources is confined to the WRB and is composed of three parts:

1. The individual project areas of the 13 multipurpose dams and reservoirs that comprise the WVS and cover approximately 55,000 acres of lands that are inundated by the reservoirs, have Corps infrastructure at the dams and around the reservoirs, and are uplands surrounding the dams and reservoirs,

2. The approximately 465-mile river system that is controlled by the WVS, starting at the 13 reservoirs on the Willamette River and its tributaries and ending at Willamette Falls in Oregon City, Oregon, and

3. Discrete and limited sections of the Calapooia, Clackamas, and Molalla Rivers and Mill Creek where revetments are located that could be modified in some of the alternatives, but are not downstream of the WVS and not regulated by the Corps.

The downstream area of analysis is derived to align with Section 3.2 that explains the maximum extent of the WRB waterways that are controlled by the WVS and Section 1.6.1 that summarizes the Willamette River Bank Protection Program that originally constructed existing revetments that are not downstream of the WVS but to which modifications are being considered as part of the Draft PEIS. The upstream area of analysis was derived through consideration of the potential maximum extent of impact if there were to be operational or infrastructure changes at the dams and reservoirs. The maximum extent of the upstream area of analysis includes the footprints of the 13 individual projects to cover any potential staging and work zones that may result as part of implementing any operational or infrastructure changes.

This section provides a summary of WRB history, which informs the reader of the kinds of cultural resources that may be present in the area of analysis. Between 1953 and 2021, cultural resources specialists have conducted several surveys to identify cultural resources within the footprint of 13 individual projects areas of the WVS; the results of these surveys and related resource forms are held by the Corps Portland District. These surveys allow for a quantitative component of this analysis that considers the number and type of documented cultural resources that could be impacted by the alternatives regardless of listing in federal, state, or local registers. Cultural resources are highly susceptible to unauthorized excavation and collection, and as a result, any discussion of cultural resources would be broad, and any quantitative components would be averaged and aggregated.

For the riverine settings downstream of the 13 individual projects of the WVS, these lands and waterways are not managed by the Corps and are a mix of other federal, tribal, state, municipal, county, and private ownership. These non-Corps lands have been surveyed to varying degrees, and there is no efficient way to obtain related resource data within the 465-

mile riverine setting that would allow for a quantitative analysis, with the exception of some inventory data related to revetments in the WRB. Potential impacts downstream of the dams are not anticipated to vary across the alternatives, however, because the WVS would retain the Congressionally-authorized purpose of flood risk reduction regardless of the preferred alternative. As discussed in Sections 3.2, the measures that consider operational changes would occur mostly outside of the flood season (November through February) when peak flows typically occur and are reduced by the WVS to decrease damage from flood inundation. Given that the WVS is anticipated to continue flood risk reduction, and future impacts to cultural resources downstream of the 13 individual projects that could occur in the future would not be the result of operations or infrastructure changes described in the Draft PEIS, the discussion of cultural resources downstream of the WVS would be limited to summary overview of the cultural history of the Willamette Valley.

### 3.21.1 Affected Environment

The pre-contact, ethnographic and historic sections are taken from several overview documents commissioned by the Corps to describe and understand the cultural history of the WVS area as well as its place in the greater WRB. These references include Lewis (2020), Linville and Root (2021). Provost et al. (2019), Root et al. (2020), Toepel and Beckham (1982), and Willingham (1983). The following text has been edited and in text citations removed for clarity and readability.

#### *3.21.1.1 Pre-contact Background*

The earliest archaeological evidence of human occupation in the WRB is associated with rare discoveries of projectile points associated with the Paleo-Indian Period (time range of 15,000-9,000 years B.P.), many of which were recovered in or near Corps reservoirs. Finds of Clovis points across the western United States suggest a widespread occupation where humans used a variety of landforms and resources. A square stemmed sub-type of projectile points is found in the western Cascades including at Detroit and Lookout Reservoirs that may be indicative of a similarly early occupation known as the Western Stemmed Tradition. Paleo-Indian peoples were originally thought to have been highly mobile foragers who relied primarily on large game, specifically megafauna, though this is debated in archaeological research. Megafauna generally would have been unavailable in the WVB during the period between about 10,000 - 8,000 B.P.; however, bison may have persisted in the region and other large ungulates would have supported human populations in the area. Evidence of acorn use was reported at a Willamette Valley site, dating to approximately 10,000 B.P., and hazelnuts have been found in a similarly aged hearth along the Long Tom River.

The transition from Paleo-Indian to Early Archaic archaeological cultures (time range of 9,000-6,000 years B.P.) is marked by more diverse flake stone artifact assemblages, including both formal (carefully crafted for a specific purpose) and expedient (on-the-fly and quickly made) tools. This pattern is found in the Great Basin, the Columbia Plateau, and Willamette Valley. The earliest camas ovens in the Willamette Valley date to this period, showing that people mass processed the bulbs of the camas plant by 8500 B.P. The economic system implied by an expanded flaked stone toolkit, but limited groundstone technology, is associated with the seasonal movement of Early Archaic peoples and harvesting of large and small mammals and plants across multiple ecological zones. The increased evidence of plant (specifically camas) processing in the archaeological record associated with the Early Archaic period may indicate population growth in the Willamette Valley.

The Middle Archaic period in the Willamette Valley is marked by two technologies: camas ovens and wide necked dart (atlatl) points (time range of 6,000-2,000 years B.P.). Foliate-shaped Cascade points, first used in the Early Archaic period, were still used in this period, and Willamette Valley inhabitants continued to rely on flaked stone technology much like their predecessors; however, innovations and increased use of groundstone technologies are evidenced in the archaeological record. During this period, land use patterns began to shift, and Willamette Valley occupations appear centered on camas use and exploitation of the High Cascades for summer resources and obsidian, the latter becoming an interregional commodity. The Middle Archaic can be viewed as transitional between the highly mobile lifeways of the Early Archaic and increased sedentism in the Late Archaic, during which seasonal use of stored plant food staples allowed people to return to the same locales year after year. Camas oven features, associated with charred camas bulbs, hazelnuts, and acorns have been found at several sites in the Willamette Valley. While the earliest camas ovens date to 8500 B.P., the increased scale of camas oven use in the Middle Archaic implies heavy investment in processing a seasonal resource and suggests that storage, a prerequisite for sedentism, occurred. A second indication of the intensification in plant processing was the presence of labor intensive grinding implements such as mortars and stone bowls. Stone bowl fragments were found at the Mill Creek and Long Tom sites.

The Late Archaic is the period during which traditional lifeways appear to have been similar to those documented in the ethnographic record (time range of 2,000-250 years B.P.). During this period, some archaeologists suggest that lifeways and cultural adaptations became more localized, with some patterns correlating with historically recorded ethnic and linguistic boundaries. However, there is limited ethnographic data available for the Molalla people of the Western Cascades, so archaeologists have developed lifeway models that extrapolate Willamette Valley (Kalapuyan) economic patterns into higher elevation river valleys. This tension between local differentiation and regional integration is shown in several developments in the Late Archaic. Technologically, the Late Archaic period is marked by the arrival of the bow and arrow and continued high investment in plant processing technologies including stone bowls and mortars. The Late Archaic is also marked by an increase in sedentism, expanding diets, and the development of status differences demonstrated by the attainment of long-distance trade goods. The first evidence of fish and freshwater mussels is seen in this period, indicated by midden deposits built up over repeated reuse of house or village locations.

The continuity of such exchange into the historic period is apparent in the presence of exotic items in 19$^{th}$ century ethnographic collections from Grande Ronde. Items indicating long-distance exchange include a purse containing dentalium (tooth shells or tusk shells) from Vancouver Island, a decorated horn bowl from the Wasco Tribe near The Dalles, a horn spoon from Puget Sound, and a buffalo hide parfleche from east of the Cascades. Several items in the collections have oral histories that date them to before European colonization, suggesting that exchange networks remained robust into the 19th century.

#### *3.21.1.1.1 Ethnographic Summary*

The Willamette Basin at the time of Euroamerican contact (i.e., early 19th century), represented a culturally distinct region of several groups of peoples. These Willamette Basin groups were separated from the Chinookan peoples of the Lower Columbia River by the Willamette Falls. Willamette Basin groups identified themselves and related to each other according to kin affiliations, resource use, and other factors. Ethnographers commonly refer to Willamette Basin peoples in linguistic terms of either “Kalapuya” or “Molalla”-speaking.

#### *3.21.1.1.2 Kalapuya Ethnography*

The Kalapuya lived in a region of the Willamette Valley bounded on the west by the Coast Range, the south by the Calapooya Mountain range, the north by the falls of the Willamette River, and the east by the Cascade Mountains. The Yoncalla, the southernmost of the many Kalapuya tribes, lived on the south side of the Calapooya Mountain Range along Elk and Calapooya Creeks.

In the southern portion of the Willamette Valley, there is archaeological evidence that settlement patterns were dispersed and consisted of small family groups composed of one or more base camps to pursue seasonal resources. These base camps were located in different areas, and the Kalapuya groups moved between them as resources became available, primarily gathering and processing plant foods and hunting and processing mammals and birds. A similar pattern occurred in the northern Willamette Valley. Ethnographically, the Tualatin (another major Kalapuya Tribe) are reported to have lived in as many as 15 to 20 villages in the winter, mainly on the Tualatin Plains and in the Wapato Lake area.

Kalapuya people camped on the floodplains of rivers during the summer. The Santiam Kalapuya tale of Coyote Rose Hips corroborates this claim with a description of Coyote’s house by flowing water. Shelter was not taken except during inclement weather, in which case a temporary house of grass or brush over fir boughs was erected, or temporary huts of pine branches were built under oak trees as wind breaks.

Researchers estimate that between 3,000 and 16,200 Kalapuyan people lived in the region prior to contact with Euroamericans. Kalapuya numbers had diminished substantially before ethnographic documentation began, with mortality estimates as high as 95 percent between 1770 and 1840. There are several cultural groups who reportedly identified, or were identified, as Kalapuyan, and about whom some ethnographic information has been documented in written records. These include the Tualatin, Yamhill, Luckiamute, Santiam, Yonkalla, Mary’s River, McKenzie, and Calapooia.

According to sources from 1792 to 1830, there was a complex network of marriages, shared access to resources, and trade in the Greater Lower Columbia area that linked many cultural groups living along the coast (from the Makah to the Alsea) with the Tualatin Kalapuya. The Kalapuya participated in a trade network, exchanging fur, obsidian, bone, tools, shells, dentalium, and other materials and acted as brokers in the fur trade between Vancouver and the southern interior around the early 19th century. The Kalapuya were open to many cultural influences by means of trail systems, from peoples of the Cascade Mountains, and from peoples of the rivers extending from the coast and from northern California. Trade relationships existed between not only Kalapuyan subgroups, but Columbia River tribes, Molalla, Cayuse, northern California tribes, and coastal Oregon tribes based on the exchange of slaves and resources.

###### *3.21.1.1.3 Molalla Ethnography*

The cultural practices and patterns of the Kalapuya and Molalla were similar despite linguistic, geographic, and subsistence differences. There are fewer ethnographic and historical accounts that specifically address Molalla lifeways, traditions, and customs, however, leading to some generalizations between the two groups.

While the eastern foothills of the Coastal Mountains and the lower elevations of the Willamette Valley were inhabited by the Kalapuya, the western foothills of the Cascade Mountains along the Willamette Valley, as far west as the eastern side of the confluence of the Willamette and Columbia Rivers, were inhabited by the Molalla. Molalla territory (as a cultural group rather than a linguistic one) included the Oregon City Falls, Molalla River tributaries, and southwestern tributaries of the Clackamas River. The Molalla have been typically identified as Northern Molalla, who inhabited the Santiam and Willamette River west of Mt. Hood and lands to the north along the western and high lands of the Cascade Mountains, and Southern Molalla. The history and culture of the Southern Molalla is not well documented, except for a handful of post-contact accounts of Native peoples in the valley of the Willamette River’s Middle Fork tributary.

The Molalla were mobile in the summer and sedentary in the winter. The Molalla followed a seasonal round of hunting and gathering in the Cascades. The Molalla River Valley was an excellent area to gather berries and to hunt for elk, as implied by parsing of the word “Molalla” into “moolock” (elk) and “olille” (berries). Some temporary villages were located in the mountains approximately 30 miles east of Albuqua River and were most likely summer settlements. A group of 30 intermarried Klamath and Molalla families regularly inhabited the Cascade Mountains during the summer and the Willamette Valley during the winter. In the winter, the 30-family Klamath-Molalla group inhabited the Middle Fork area of the Willamette River near Butte Disappointment, just south of Fall Creek Lake, at a placed called “Demijohn’s Tower”. Once a landmark in the area, the steep slope of Demijohn’s Tower has since been impacted by the Fall Creek Dam construction, erosion, and commercial mining.

#### *3.21.1.2 Historic Background*

European epidemics among native populations in the Pacific Northwest preceded direct Euroamerican contact and caused drastic indigenous depopulation. Consequently, changes to sociopolitical alliances and territorial boundaries occurred as surviving populations adapted. European and Asian diseases such as smallpox reportedly affected Native American populations in the Northwest as early as 1782 and again in 1797, spreading inland from contact along waterways. Despite these diseases, a Native informant (of unrecorded origin) to Lewis and Clark reported in 1806 that the “Calloh-po-e-wah nation” was very numerous.

By the second decade of the 19th century, the quest for furs led explorers into the watershed of the Willamette River. In 1805 and 1806, Meriwether Lewis, William Clark, and the Corps of Discovery had examined the lower reaches of this stream. In 1811 with the establishment of John J. Astor's fur trading post at the mouth of the Columbia, the stage was set for more intensive land-based exploration and utilization of resources. Central Kalapuya peoples, including those along the Middle Fork of the Willamette River in the vicinity of present-day Eugene and the Fall Creek Lake area, first came into contact with Euroamericans in 1812. During the early 19th century, the trapping industry began to outcompete that of the Kalapuya along the tributaries of the Willamette River, impacting a portion of the Kalapuyan trade-based economy. This had the additional effect of depleting the beaver and game animal population, which greatly reduced Kalapuyan access to these resources.

By the mid-1820s, explorers and fur seekers began passing regularly through the Upper Willamette Valley. Between 1830 and 1831, Euroamerican-introduced “fever and ague” (most likely malaria) led to major population decreases among the indigenous populations in the Columbia Basin below Celilo Falls. It was estimated that 5,000-6,000 people surrounding the Willamette River died within two years (1830-1831) due to a combination of malaria, venereal diseases, wet weather exposure, and starvation, and that the populations continued to halve every two to three years for about a decade, leaving 600 Kalapuya remaining in 1841. Census information indicates that 300 people remained of the indigenous population in the Willamette River valley in 1844, and only a small number of Kalapuya were among them.

By the 1840s, a number of factors drew Euroamerican settlers to Oregon Territory. The promise of abundant and possibly free land, an escape from debt and the depression following the Panic of 1837, the allure of a healthy climate and adventure, the promotion of publicists, and the challenge of making Oregon an American possession all beckoned to those who were willing to migrate westward. Thousands did, and by 1846 they began settling in the Upper Willamette Valley. Within a period of six years, through the Donation Land Act of 1850, mostly white families had taken up claims throughout the region. The arrival of the claimants not only dislocated many Native peoples from their lands but also led to severe depletion of the resources traditionally sustaining them by means of fire suppression, overhunting, overgrazing, and water pollution that impacted fish runs. The expansion of non-Native communities into indigenous territories ultimately led to conflict for land, resources, and the right of indigenous communities to exist in the Willamette Valley.

Multiple treaties drafted in the 1850s, by Oregon Territory and Bureau of Indian Affairs officials stated that the U.S. government would provide for reservations within the homelands of the Kalapuya and Molalla if they ceded large tracts of their territories, and that rights would be reserved to these groups for subsistence at their usual and accustomed places. However, these treaties were unratified. Eventually, treaties ratified in 1855 extinguished Kalapuya and Molalla title to their lands for a much smaller reservation of land and required them to relocate to the Grand Ronde Reservation. In 1856, the push was made for all Willamette Valley tribes to move to the Grand Ronde or Oregon Coast (or Siletz) reservations. The majority of Kalapuya and Molalla people ended up at the Grand Ronde Reservation, however, individuals, families or small groups incorporated into the Klamath or Warm Springs reservations. Some people chose to remain in their homelands, and as a result, they faced harassment from government agents who had been charged with the task of ensuring the removal of all Native peoples in order to "open up" the land for settlement. For example, the Calapooian chief "Cam-a-phee-ma" and his family refused to leave their homeland in the Yonkalla territory despite being threatened with death by a government agent.

In 1862, the Homestead Act allowed more settlers to obtain as much as 160 acres of public domain by proving up on a claim. Eugene, Springfield, and Cottage Grove emerged as the important larger towns in the 19th century. The building of the Oregon and California Railroad through the Upper Willamette Valley in the 1870s contributed to the development of additional townsites at Goshen, Creswell, Latham, and Divide. The growth of towns, as well as the increasing number of post office stations in this region, reflected the swelling non-native population which continued to push deeper into the more rugged portions of the Upper Willamette River valleys.

The United States Bureau of the Census of 1900 recorded only one Native American family in the Middle Fork region; however, many indigenous people who remained in the Willamette Valley kept a low profile by not reporting for census counts or blending into mostly white communities. Members of the Warm Springs Reservation reportedly visited the area annually (up until the second decade of the 20th century) to pick hops on lands owned by A.D. Hyland at the city of Lowell. Warm Springs Reservation members also continued to visit the area to fish for salmon, pick huckleberries, and hunt, returning to the reservation in early fall with dried and fresh fruit, clothing, and salmon. Henry Yelcus, who was reportedly the last Molalla person to continue living in the Molalla-Dickey Prairie remained until his passing in 1913.

While the Willamette River waterways became heavily populated, for years the forests had discouraged non-Native settlement or had served as obstacles to those who sought to turn these lands into agricultural areas. The availability of a transportation system in the last decades of the 19th century changed this, and within a short period sawmill operations became important sites of industry and employment. Lumber production mounted steadily in Lane County from 774,000 board feet in 1865 to 10.5 million board feet in 1895. While many small sawmills were set up along the rivers and in rural areas, by 1900 major timber companies began combined logging and lumbering enterprises. The timber business continued to grow through the first seven decades of the 20th century. From the 1920s into the 1960s, many small operators cut trees and produced lumber for the booming market along the Pacific Slope. In the 1960s and following, however, the small operators were shoved aside, and the large corporations emerged to dominate the business. Increasingly these firms were dependent upon the purchase of BLM and U.S. Forest Service logs through federal timber sales.

*3.21.1.2.1 Federal Government Actions*

From initial exploration efforts in 1841 to a series of ventures in the 1850s, the America government was important in developing information about the resources and potentials of the region. Of singular importance were the land grants to the Oregon Central Military Wagon Road and the Oregon and California Railroad. These actions of Congress in the 1860s spurred the development of key transportation routes or systems which linked the Upper Willamette to larger markets and influences.

The revestment (return of land to the government) of the Oregon and California Railroad (O&C) grant lands in 1916 and the creation of the Cascade National Forest – later the Willamette National Forest — were important actions prior to World War I that put the government into extensive land management in the watershed of the Upper Willamette River. Eventually, following World War II, the functions of the General Land Office were broadened under the new Bureau of Land Management, and specific policies of timber harvest and sales from O&C and other public lands assumed increasing importance in the region's economy. Of similar importance were the actions of USACE to work with local industry to provide for flood control in a series of reservoirs and for hydroelectric power generation throughout the Willamette Valley, built between 1940 and 1969. This was part of a national trend where the Corps oversaw hundreds of civil works projects throughout the United States.

*3.21.1.2.2 The Portland District and Willamette Valley Project*

In 1871, the Corps established the Portland District to ensure management and control of the Columbia and Willamette Rivers as navigable waterways. In the later 1800s and into the early 1900s, the Portland District focused much energy to “improve” waterways of the region. By 1876, river traffic had increased substantially along the Columbia and Willamette Rivers. By the 1880s, the Corps had also built civil works projects on the Oregon Coast. In 1896, the Corps constructed the first canal project on the Columbia (the Cascade Locks and Canal), and between 1905 and 1915, the Corps completed The Dalles-Celilo Canal. Local efforts also resulted in several private water resource projects including the building of the Willamette Falls Locks, in 1873, which the Portland General Electric Company (formerly known as the Willamette Falls Canal and Locks Company) later sold to the Corps in 1915. Many of these efforts inundated, destroyed, or cut off access to places and resources integral to the Native American economy of the Pacific Northwest including several notable points along the rivers where large gatherings had occurred for centuries and where sizeable fish runs had sustained local populations.

A prime example of this is located at the northern extent of the area of analysis. Willamette Falls, at River Mile 26.5, has been an important meeting place for generations of Native Americans throughout the Pacific Northwest. According to recent radiocarbon dating of archaeological components at the falls this legacy is at least 1400 years old, but likely extends back several millennia. The location is now fully ensconced within the city limits of Oregon City, at the southern end of the large population that surrounds the Portland Metro area. Despite this heavy industrialization of the area, it continues to be an important fishing locale for several federally recognized tribes throughout Oregon and Washington including the Confederated Tribes of Grand Ronde, the Confederated Tribes of Warm Springs, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of Siletz Indians, and the Confederated Tribes and Bands of the Yakama Nation.

This customary use of the falls continues even though Euroamericans laid claim to the area as early as 1828, starting with John McLoughlin of the Hudson Bay Company, with later capital ventures to industrialize the area (with grist, woolen, saw, and paper mills), and to facilitate navigation with the installation of the locks. As recently as 2011, the Blue Heron Paper Mill operated near the falls but was ultimately demolished in 2021. The Willamette Falls Locks was listed in the National Register of Historic Places in 1974 but has been non-operational since 2011. The complex multicomponent landscape that surrounds and includes Willamette Falls is composed of archaeological sites and built resources including urban sprawl of historic Oregon City.

By the 1920s, state and local entities attempted to initiate programs to promote the further development of navigation and flood control on the Columbia River. The Columbia Valley Association, a private organization that advocated for development in the Columbia River Basin, held meetings with business groups and other organizations to promote improvement projects. A similar group, the Willamette Valley Association, was founded in 1933. Much like the Columbia Valley Association, this organization spearheaded multiple efforts to attain federal support for improvements to the Valley's waterways. The seemingly rampant floods that struck in Oregon and across the nation in the 1920s and 1930s helped to inspire Congress to pass the Flood Control Act of 1936, a milestone in federal water resources policy. The Act was monumental in that it made flood control a priority of the Corps. In terms of the WVS, the Act became the basis for the Corps to plan, design, and ultimately construct the first dams of the Willamette Valley. As discussed in Section 1.5, the Corps constructed 13 dams and reservoirs between 1940 and 1969 through the Flood Control Act of 1938, 1948, 1950, 1954, and 1960 (Table 3.21-1).

**Table 3.21-1. Contributing Resources of the WVS Historic District**

| Project | Dates of Construction | Authorizing Flood Control Act |
|---|---|---|
| Fern Ridge | 1940-1941 | Flood Control Act of 1938 |
| Cottage Grove | 1940-1942 | Flood Control Act of 1938 |
| Dorena | 1940-1949 | Flood Control Act of 1938 |
| Big Cliff | 1949-1953 | Flood Control Act of 1948 |
| Detroit | 1948-1953 | Flood Control Act of 1938 |
| Dexter | 1953-1954 | Flood Control Act of 1950 |
| Lookout Point | 1947-1955 | Flood Control Act of 1938 |

| Project | Dates of Construction | Authorizing Flood Control Act |
|---|---|---|
| Hills Creek | 1956-1962 | Flood Control Act of 1950 |
| Cougar | 1956-1964 | Flood Control Act of 1950 |
| Fall Creek | 1961-1965 | Flood Control Act of 1950 |
| Green Peter | 1963-1967 | Flood Control Act of 1954 |
| Foster | 1964-1968 | Flood Control Act of 1960 |
| Blue River | 1963-1969 | Flood Control Act of 1950 |

*3.21.1.2.3 Documented Cultural Resources in the Area of Analysis*

The deep history of human habitation of the Willamette Valley has left tangible markers on the landscape now managed by the Corps. There are 461 documented pre-contact, historic, and multi-component archaeological resources within or intersecting with the footprint of the 13 individual WVS projects. These resources range in age from the earliest documented Paleo-Indian Period projectile points to very recent dam construction work areas of the mid-20th century, circa 1941-1972 A.D. (**Error! Reference source not found.**). Archaeological resource types include isolated artifacts and features, diagnostic task sites, non-diagnostic debris sites, one historic cemetery, residential sites, transportation/travel corridors, townsites, rock features, rockshelters, lithic scatters, etc. Portions of the WVS built environment are also eligible for National Register of Historic Places (NRHP) listing and consists of 13 historic districts with 89 contributing resources that were constructed between 1941 and 1972 (**Error! Reference source not found.**2).

**Table 3.21-2. Archaeological Resources in the WVS by Project**

| Project Name | Archaeological Resources | Contributing Resources in WVS Historic Districts |
|---|---|---|
| Big Cliff | 2 | 3 |
| Blue River | 12 | 4 |
| Cottage Grove | 24 | 6 |
| Cougar | 31 | 6 |
| Detroit | 31 | 4 |
| Dexter | 12 | 5 |
| Dorena | 14 | 6 |
| Fall Creek | 55 | 3 |
| Fern Ridge | 181 | 23* |
| Foster | 38 | 10 |
| Green Peter | 20 | 9 |
| Hills Creek | 4 | 4 |
| Lookout Point | 37 | 6 |
| Total | 461 | 89 |

*Includes the Lower Long Tom Constructed Channel

The WVS is locally significant (as the term is defined in the NHPA) and eligible for listing in the NRHP as 13 historic districts due to its impact on the development of the Willamette Valley Basin in Lane, Linn, Marion, and Benton counties between 1940 and 1972 (known as the Period of Significance, or POS). During this time, construction of the dams, reservoirs, appurtenant infrastructure, fish passage systems and hatcheries, as well as recreation sites of the WVS had major influences on the Willamette Valley through implementing a flood control mission that changed the way people settled the landscape, earned a living, accessed river resources, and recreated in the Willamette Valley. The construction of a series of large-scale infrastructure projects mobilized the local workforce, providing job opportunities and civil pride in American ingenuity and engineering feats. These projects developed recreational opportunities and related commerce throughout the Valley, instilled in the public that reservoirs and dams are places to recreate, developed and provided hydropower, and impacted native fish runs and the human response to address these impacts. It also applied innovative engineering (research and design, or R&D) to facilitate anadromous fish passage through the WVS and to boost local fish populations through hatchery programs. **Error! Reference source not found.**3 provides the types and count of contributing resources of the WVS historic districts that retain integrity, can be dated to the POS, and are directly associated with the historic themes that make the WVS historically significant to history of the Willamette River Basin.

**Table 3.21-3. Contributing Resources of the WVS Historic Districts**

| Resource Type | Contributing Resources | Notes |
|---|---|---|
| Dam | 13 | All dams are contributing |
| Powerhouse | 8 | All powerhouses, except Dexter, are contributing |
| Reservoir | 13 | All reservoirs are contributing |
| Stilling Basin | 1 | Foster |
| Ancillary Dikes/Levees | 2 | Fern Ridge |
| Saddle Dam | 1 | Blue River |
| Engineering Project Office | 3 | Cougar, Dorena, and Hills Creek |
| Caretaker's Facility | 2 | Fern Ridge and Foster |
| Garages | 2 | Fern Ridge and Foster |
| Fish Passage Facilities | 4 | Dexter, Foster, and Green Peter |
| Recreation Areas | 30 | All projects, except Big Cliff, Dexter, and Hills Creek |
| Channel/Drop Structures | 10 | Lower Long Tom Constructed Channel (part of Fern Ridge Project) |

To date, there are no identified TCPs or HPRSCITs documented in the 13 project areas. However, given that Kalapuya and Molalla peoples have inhabited the WRB for millennia, there are likely many.

As discussed in Section 1.6, the Corps has a structural footprint, with historic-age components, that extends beyond the WVS with the Willamette River Basin Bank Protection Program (WRBBPP), the Willamette Hatchery Mitigation Program, Fish Mitigation program, and the Research, Research, Monitoring, and Evaluation (RM&E) program. The WRBBPP program constructed 223 flood control structures in the WRB, of which 193 are still active and are at least 50 years of age. These resources have not been evaluated for listing in the NRHP. Associated with the remaining programs, downstream of the dams, the Corps constructed and operates five adult fish collection facilities and funds the operations and maintenance of five hatcheries that are downstream from the WVS dams, as listed in Table 3.21-4. All of the collection facilities and hatcheries have components that are at least 50 years of age, though the majority have been majorly modified or upgraded with new facilities to support fish populations in the WRB. For any actions that require modification to the built environment that support these Corps programs, an inventory and evaluation would be required to determine if the infrastructure or components are eligible for listing in the NRHP.

**Table 3.21-4. Corps-constructed Fish Hatcheries**

| Hatchery Name | Year Completed | Notes |
|---|---|---|
| Dexter Holding Ponds* | 1954 | Located at Dexter Dam; Mitigation for Dexter; now part of Willamette Hatchery |
| Leaburg Fish Hatchery | 1953 | 18.5 miles west of Cougar Dam; Mitigation for Blue River and Cougar |
| McKenzie | 1938, 1975 | Rebuilt in 1975; Mitigation for Blue River and Cougar |
| Marion Forks | 1951 | 17.5 miles southeast of Detroit Dam; Updated in 1986 and 2013; Mitigation for Detroit and Big Cliff |
| Minto Fish Facility | 1953, 2013 | 3.8 miles west of Big Cliff Dam; Rebuilt 2013; mitigation for Detroit and Big Cliff |
| Oakridge Salmon Hatchery | 1911, 1952 | 2.65 miles north of Hills Creek Dam; Rebuilt in 1952; mitigation for Hills Creek, Lookout Point, and Dexter; now part of Willamette Hatchery |
| South Santiam* | 1968 | Located at Foster Dam; Mitigation for Green Peter and Foster |
| Willamette Trout Hatchery | 1922, 1950s | 2.65 miles north of Hills Creek Dam; Rebuilt in the 1950-56; now part of Willamette Hatchery |

### 3.21.2 Environmental Consequences

This section discusses the potential effects of the alternatives on cultural resources in the WVS within the life of the project (30 years).

#### *3.21.2.1 Methodology*

The methodology used to determine potential effects to cultural resources and the nature of those effects are discussed below by resource type including archaeological sites, built resources, and traditional cultural properties. In the WVS, archaeological sites are most vulnerable to surface exposure and erosion that destroy the physical integrity of the site and expose artifacts to humans who may illicitly collect artifacts or vandalize sites, while built resources are most vulnerable to physical modifications that change aspects of contributing elements that are part of its historic fabric and make it eligible for listing in the National Register of Historic Places. The condition of traditional cultural properties are negatively affected when the people who value those places have reduced access to the location or resources or are affected by unappealing aesthetic at the location due to modification.

The cultural resources effects analysis relies heavily on qualitative discussion of how a proposed action would directly impact a resource type (e.g., erosion, exposure, modification, etc.) because the Corps does not collect quantitative data that would allow for measurable changes in cultural resources condition such as annual rates of erosion or actual days of exposure for archaeological sites or a presence-absence or wellness indicator for resources that should be present at traditional cultural properties. Once the understanding of how an action would affect a resource type is documented, however, it is possible to quantify the number of cultural resources that would be directly exposed to that action, and then compare the total number and types of resources impacted by alternatives. In the case of archaeological resources, once the count and acreage of sites that would be impacted by an action is tabulated, it is possible to use GIS and ResSim outputs to model a baseline of impact as a result of exposure (due to operations and measures in the No Action Alternative) and then compare how effects from actions that cause site exposure would vary across alternatives.

All of the alternatives propose operational measures (as opposed to structural measures) that are large in scale and would continuously and directly affect a large number of cultural resources, most notably several hundred archaeological sites, throughout an entire reservoir and across several reservoir projects throughout the duration of the proposed period of analysis (life of the project, 30 years). Impacts from operational measures to archaeological sites would be permanent, however, and therefore extend well beyond 30 years. Due to the longevity and widescale nature of these operational measures and the overarching WVS flood risk management mission, which requires actions that affect large numbers of documented archaeological sites, the evaluation criteria to assess potential effects to cultural resources is best understood on a holistic level. The criteria that would evaluate the potential impacts of each alternative address effects at the population level that are categorized as Negligible, Minor, Moderate, and Major as shown in Table 3.21-5.

**All comparisons of effects for each action alternative are in comparison to the NAA unless stated otherwise.**

**Table 3.21-5. Evaluation Criteria for Potential Effects to WVS Cultural Resources**

| Effect Scale | Criteria |
|---|---|
| Negligible | Changes, whether adverse or beneficial, occur to zero or a limited number of cultural resources and is a limited proportion of all known cultural resources by reservoir project (<1%). The impact to the known cultural resources in the WVS is negligible, and the effects are not demonstrable at the local, project-specific, or system level. These impacts would be short-term and reversible or result in no change to current conditions. |
| Minor | Changes, whether adverse or beneficial, occur to a small number of cultural resources and is a small proportion of all known cultural resources by reservoir project (1.1-5%). The impact to the known cultural resources in the WVS is minor, and the effects are demonstrable only at the local or project-specific level. These impacts would be short-term, or if longer-term, easily reversible. |
| Moderate | Changes, whether adverse or beneficial, occur to many cultural resources and is a greater proportion of all known cultural resources by reservoir project (5.1-10%). The impact to the known cultural resources in the WVS is moderate, and the effects are demonstrable at the local, project-specific, and system level. These impacts would be long-term but potentially reversible. |
| Major | Changes, whether adverse or beneficial, occur to a high proportion of all known cultural resources by reservoir project (>10%). The impact to the known cultural resources in the WVS is major, and the effects are demonstrable at the local, project-specific, and system level. If adverse, these impacts would be permanent and irreversible. In the case of built resources, the changes would be long-term but could be reversible, but would require much effort to revert to prior conditions. If beneficial, the change would result in rehabilitation to original conditions or stabilization that stops future degradation to the resource. |

#### *3.21.2.1.1 Archaeological Sites*

The range of alternatives have the potential to effect archaeological sites through actions that cause erosion and exposure. Erosion is directly caused by measures that result in reservoir elevation change, most notably reservoir draft and fill cycles that are routine in flood risk management systems. During draft and fill cycles, archaeological sites that are located within three feet of the drawdown elevation (either above or below the elevation line) are exposed to wind and resulting wave action that cut into soils and disturb archaeological materials contained in the soils. Reservoir soils are routinely desaturated and then inundated, and as a result do not have much if any stabilizing vegetation cover. These unprotected soils are susceptible to splash erosion (when raindrops impact bare soil, soil surface sealing develops and water does not infiltrate the soil, and soil particles break off from soil aggregate and are displaced) and sheet erosion (water runoff removes thin layers of fine particle soil) from rainfall and water runoff. Exposed reservoir beds, particularly on slopes or where there is uneven and linear down sloping topography, are susceptible to rill erosion (when water runoff forms small channels as it moves downslope) and gully erosion (water runoff forms deep channels through soil). When exposed, tributaries that flow into the main river channel would also downcut soils along the water path further increasing unstable and deeply furrowed channels. Mass wasting events (e.g., landslides, rockfalls, soil creep) or the process of bank or terrace erosion also occur along the shores of reservoirs or within the reservoir where other forms of erosion have made landforms vulnerable to undercutting and slumpage. All types of erosion in reservoirs are related to continual exposure of non-vegetated soils to wind and water movement as well as repeated changes to overall environment, through draft and fill cycles. When drafting is accelerated over the threshold of 3 ft/day, through a deep drawdown, the reservoir beds remain saturated and do not have time to fully drain and stabilize resulting in episodic slope failure throughout the reservoir.

Routine changes in reservoir elevation result in sediment movement, particle sorting, and removal of fine grade sediments that slowly deflate archaeological sites and expose archaeological materials to the surface of the reservoir beds. This action not only erodes and further damages the physical integrity of archaeological sites, but it also exposes resources that are typically covered by water and the sites become vulnerable to human-induced effects. These include unauthorized artifact collection, knowingly or unknowingly digging into and damaging the physical integrity of archaeological sites, and side effects of unauthorized recreation (e.g., driving vehicles, rockhounding, or metal detecting in the reservoirs).

Cyclical, continual, and frequent erosion and exposure have lasting and irreversible effects to archaeological sites that cannot be fixed or rehabilitated. The best case scenario for archaeological resources is to reduce or stop actions that actively degrade physical integrity to either slow the pace of effects or stabilize the site in its current condition. The draft and fill cycle that occurs each water year has annual effects to archaeological sites, but also build off of several decades of incremental site degradation resulting in major loss to site integrity. The Corps has not actively studied rates of site erosion or exposure in the WVS, but recent subsurface evaluations of archaeological resources and a steady program of site condition assessments, in 2020-2021, have identified noticeable degradation of archaeological resource due to active erosion and human-induced impacts (mostly unauthorized surface collection of archaeological artifacts). With this in mind, discussion of erosion and exposure levels is weighted toward qualitative assessment of the potential effects the alternatives may have on cultural resources though quantitative assessments are used when possible.

The proposed measures that would affect archaeological sites are categorized by whether they result in a reservoir elevation change that would cause erosion and exposure and if they would result in a deep drawdown that would greatly increase the rate of erosion by quickly exposing soils that are not adequately desaturated at the threshold drafting rate of 3 ft/day (see Table 3.21-6).

**Table 3.21-6. Measures that Would Cause Adverse Effects to Archaeological Sites**

| Measure Number | Measure Description | Reservoir Elevation Change? | Deep Drawdown? | Notes |
|---|---|---|---|---|
| 721 | Use spillway for surface spill in summer | Yes | No | Assumes water levels higher than spillway crest to implement |
| 30a | Integrated temperature and habitat flow regime | Yes | No | Flows (and elevations) are based on fullness of reservoir on June 01. |
| 30b | Refined Integrated temperature and habitat flow regime | Yes | No | |
| 304 | Augment instream flows by using the power pool | Yes | No | Can draft to minimum power pool |
| 718 | Augment instream flows by using the inactive pool | Yes | No | Can draft to 10 feet above regulating outlets |
| 723 | Reduce minimum flows to Congressionally authorized minimum flow requirements | See Notes | No | Reduction in flows would support ability to maintain the rule curve, more stable elevation changes |
| 40 | Deeper fall reservoir drawdowns for fish passage | Yes | Yes | Target elevation 25 feet above regulating outlets |
| 714 | Pass water over spillway in spring for fish passage | Yes | No | All flows to go over the spillway when greater than 25 feet over the spillway |
| 720 | Spring reservoir drawdown to regulating outlet (to Diversion Tunnel at Cougar in Alts 2B and 3B) | Yes | Yes | Target elevation 25 feet above regulating outlets |

Deeper fall reservoir drawdowns (#40) and spring reservoir drawdowns (#720) for downstream fish passage drive noticeable increases in erosion and exposure, by drafting deeply and quickly to lower regulating outlets, extending the length of reservoir bed exposure outside of storage season, accelerated erosion due to oversaturated unstable topography, and increasing the number of draft and fill cycles that occur in one water year. Other operational measures that focus on water quality and flow, including using the spillway for summer surface spill (#721), the integrated temperature and habitat flow regime (#30a), augmenting instream flows by using the power pool (#304), augmenting instream flows by using the inactive pool (#718), and reducing minimum flows to Congressionally authorized minimum flows (#723); and operational measures that focus on downstream fish passage, including spring spillway fish passage (#714), do result in elevation changes, but these are much less drastic.

To understand the magnitude of potential effects to archaeological resources, the amount and frequency of erosion or exposure that occur in a water year should be modeled if they cannot be analyzed through direct observation. For the PEIS, it was possible to model the extent of exposure of inundated archaeological resources to compare effects of different alternatives. The analysis required two variables. First is the time period of exposure, or the number of days that a portion of the reservoir would be exposed. Second is the area of the archaeological resources. Archaeological resources can vary in size greatly, from isolated features covering just a few feet to large linear features that stretch for miles.

One way to combine these two variables (time and area) for comparison purposes is to multiply the acreage of archaeological resources in a reservoir by the number days that those acres would be exposed – in other words, an “acre-day” over the course of one water year. A single “acre-day” is the amount of exposure created when an archaeological site covering 1 acre is exposed for 1 day. In the same way, a half-acre site exposed for 2 days would also be 1 acre-day of exposure. Ten acres of archaeological site exposed for 10 days would be 100 acre-days, and so on. Archaeological resources defined as isolates or isolated finds, which are represented by point data and do not have a calculated acreage (because they cover such a small area), were not used in the analysis.

The data used to support this analysis comes from two sources. First, the information about the amount of time that particular areas would be exposed come from the reservoir operations modeling described in Section 3.2 of this EIS. See Section 3.2, Hydrologic Processes, for more details. The second part of this analysis comes from archaeological research in the reservoirs. Archaeologists have completed some inventory of the archaeological resources around and within the reservoirs. The boundaries of the archaeological resources have been recorded and converted into polygons using GIS, and these features have calculated acreage (with the exception of isolates/isolated finds). This data, combined with bathymetric information from the reservoirs, allows one to determine which sites are going to be exposed when a reservoir reaches a particular elevation. It also allows for determination of how many acres of archaeological resources are going to be exposed at a given elevation. For this analysis, the polygon site data was changed from differentially-sized vector data that did not have corresponding elevation data to equally-spaced raster point site data, each measuring 0.0032 acres in size and then paired with reservoir bathymetry from digital elevation models (DEMs) to associate each site point with a given elevation. This effort resulted in the ability to conduct fine scale tabulation of <1 acre of site by elevation and fully use the varying elevation within the area of the original polygon. This reduced overcounting or undercounting that would have occurred in the area of the original polygons if it was not partitioned and had to have an averaged elevation.

The site raster point data allowed for a summation of <1 acres of archaeological resources at a given elevation at each reservoir. Then a Microsoft Excel function was used to count all points below a given elevation, in 1-foot increments, between the maximum conservation elevation and the minimum operating elevation for each reservoir. These counts were normalized to capture site data that ranged within these maximum and minimum elevation parameters. Once counts within the appropriate range were derived, they were applied to the median daily elevations known for the EIS period of record. These outputs from ResSim include reservoir elevations spanning October 1, 1935, to September 30, 2019, and provide a timeseries with a length of a single year of exposed acres on each individual day. This information regarding acreage within each elevation interval was multiplied by the number of days that each interval would be exposed to compile acre-day measurements for each of the reservoirs. The acre-day was then calculated for each alternative at each reservoir. The difference between each action alternative and the no action alternative was also calculated at each reservoir (shown in percentage).

The analysis is only as reliable as the information that is available regarding archaeological resource locations, elevations, and boundaries. Archaeological inventory of the 13 reservoirs is incomplete, and there is differential coverage of each reservoir. The irregular coverage is largely because archaeological inventory was not completed prior to reservoir filling, and the deeper parts of the reservoirs are exposed only rarely. Project parameters also guide where archaeological surveys occur. The GIS data used here is the best available record of archaeological resources present in the WVS reservoirs. Examination of the area of recorded archaeological resources by elevational interval at each of the analyzed reservoirs shows that a greater area of archaeological sites has been recorded in littoral zone (shoreline) of the reservoirs. This pattern does not reflect precontact or historical settlement practices—it reflects the areas of the reservoirs that are easiest to access and where projects typically occur (e.g. recreation sites or operational zones).

A related concern is reliability and consistency of the bathymetric data, which came from two sources: the Corps and State of Oregon's Department of Geology and Mineral Industries (DOGAMI) Lidar dataset. Some Corps bathymetry data is more than 50 years old and based on original land surveys conducted as part of mapping each project area for eventual reservoir construction and infill. Other Corps bathymetry data is derived from aerial imagery (drone flights and fixed-wing planes, each capable of carrying different types of sensors, which in turn have varying sensitivities to collect elevation data) or hydrographic surveys that collect elevation data from multi-beam sonar soundings. DOGAMI's data was derived from aerial imagery, and many times flown while the reservoirs were at high pool, which captures water surface elevation rather than reservoir contours. Data derived from multiple sources can have varying contour ranges as well as different accuracy as to how the elevation for a given location was derived. For this analysis, the DEMs were patched together to create a mosaic that covers the 13 WVS project areas. As much as possible, elevations were checked against expected elevations of the maximum and minimum reservoir pools and anticipated elevations of documented archaeological sites.

Climate change that results in increased global temperatures and winter rains would exacerbate adverse effects to archaeological sites located in the reservoirs. The resources that are within the rule curve would continue to experience cycles of draft and fill that would inhibit landform stabilization. In the summer and fall months, hotter temperatures and less water would result in lower pool elevations that would increase the exposure of higher elevation sites for longer periods of time. These resources would also be impacted by another erosional drafting event. In the winter, when reservoir elevations are at their lowest, increased rains would continue to erode the bare reservoir surfaces until reservoir fill occurs in the following water year. The amount of time that archaeological sites are exposed to human-induced impacts would also increase. In general, climate change within the flood risk management system would exacerbate erosion and exposure processes that adversely affect archaeological site integrity.

Any measures that require construction or modification of infrastructure have the potential to cause direct effects to archaeological sites through ground disturbance and staging of equipment or short-term reservoir elevation changes that would cause erosion and exposure, however, the Draft PEIS will discuss general qualitative effects from construction at the programmatic level. Site specific effects would need to be considered during any tiered NEPA analysis and resultant design planning (see Built resources discussion below). Measure 384, which includes gravel augmentation, would require screening prior to implementing the action to ensure that gravels are not being taken from or depositing on archaeological sites present in the WVS.

Some measures would not cause effects to archaeological sites (Table 3.21-7).

**Table 3.21-7. Measures that Would Have No/Negligible Effect to Archaeological Sites**

| Measure Number | Measure Description |
|---|---|
| 166 | Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams |
| 174 | Structural improvements to reduce total dissolved gas |
| 479 | Foster fish ladder temperature improvement |
| 719 | Adapt hatchery program |

##### *3.21.2.1.2 Built Resources*

Several structural measures are proposed that have the potential to affect the built environment of the 13 historic districts in the WVS. These include small and large modifications to existing infrastructure to constructing new buildings and facilities to support upstream and downstream fish passage. When assessing potential effects to built resources, the permanence of the action must be considered as well as if the changes would occur to resources contributing to historic districts and overall effect to the historic fabric of the district itself. For the purposes of this analysis, impacts to the built environment are organized as to how localized and reversible the change would be. Negligible or minor effects would occur to a resource type (e.g., dam, reservoir, recreation areas, drop structures), but the changes would be limited to small or internal components or aspects of the contributing resource that can be hidden or are generally not noticeable when viewing the resource types listed in Table 3.21-2. The effects would also be easily reversed or changed and not result in a noticeable permanent modification to the historic district (e.g., changing the trajectory of a pipe or replacing a mechanism within a panel). A moderate effect would include impacts to a contributing resource type that are noticeable upon visual inspection of it or the historic district. These changes, however, would maintain the overall aesthetic and integrity of the historic district and not introduce incongruous components. These effects would be reversable but may be present for some or all of the period of analysis. A major effect would result in a substantial addition of infrastructure to a historic district or an action that results in changes to a resource type that causes it to lose integrity by removing or changing characteristics that make it a contributing resource type to the WVS historic districts. These changes would be long-term (throughout the period of analysis), difficult to reverse, or permanent.

With the implementation of any structural measures, it is known that the actions would have an effect on the built environment, but to what level this would occur would not be fully understood until an alternative is selected, and the design phase begins. Site-specific project details for each construction measure will be determined during the preconstruction engineering and design phase. While general, qualitative effects from construction are discussed below on a programmatic level, the more detailed, site-specific analysis will be included in the tiered EA or EIS. Table 3.21-8 lists proposed measures that would have an effect on the built environment and a range of proposed levels of effect given what is currently known about the measures. A revetment measure is included in this list, but there is a high level of uncertainty as to what level of effect may occur because the revetments have not been inventoried as part of a cultural resources survey.

**Table 3.21-8. Measures that Would Result in Changes to Built Resources and Potential Level of Adverse Effect***

| Measure Number | Measure Description | Anticipated Changes to the Built Environment | Level of Adverse Effect |
|---|---|---|---|
| 105 | Construct water temperature control tower | Effects to resource type, effects to aesthetic of a historic district | Moderate to Major |
| 174 | Structural improvements to reduce TDG | Effects to internal or minor components/aspects | Negligible to Minor |
| 479 | Foster fish ladder improvement | Effects to internal or minor components/aspects | Negligible to Minor; Moderate to Major |
| 392 | Construct structural downstream fish passage | Effects to resource type, effects to aesthetic of a historic district | Moderate to Major |
| 52 | Provide Pacific lamprey passage and infrastructure | Effects to resource type, effects to aesthetic of a historic district | Moderate to Major |

| Measure Number | Measure Description | Anticipated Changes to the Built Environment | Level of Adverse Effect |
|---|---|---|---|
| 639 | Restore upstream and downstream passage at drop structures | Effects to resource type, effects to aesthetic of a historic district | Moderate to Major |
| 722 | Construct adult fish facility | Effects to resource type, effects to aesthetic of a historic district | Moderate to Major |
| 726 | Maintenance of existing and new fish release sites above dams | Effects to resource type, effects to aesthetic of a historic district | Minor to Moderate |
| 9 | Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration | Outside of the 13 historic districts, but historic in age, requires inventory and evaluation | Unknown |

*Some alternatives consider modification of Cougar Diversion Tunnel, which is a contributing resources type to the Cougar Project Historic District.

Several measures are operational in nature and would not have an effect on built resources (Table 3.21-9).

**Table 3.21-9. Measures that Would Have No Effect to Built Resources**

| Measure | Measure Name |
|---|---|
| 166 | Use regulating outlets to discharge cold water during drawdown operations in fall and winter to reduce water temperatures below dams |
| 721 | Use spillway for surface spill in summer |
| 30a | Integrated temperature and habitat flow regime |
| 30b | Refined integrated temperature and habitat flow regime |
| 304 | Augment instream flows by using the power pool |
| 718 | Augment instream flows by using inactive pool |
| 723 | Reduce minimum flows to Congressionally authorized minimum flow targets |
| 40 | Deeper fall reservoir drawdowns for fish passage |
| 714 | Pass water over spillway in spring for fish passage |
| 719 | Adapt hatchery program |

#### *3.21.2.2.3 Traditional Cultural Properties*

TCPs or HPRCSITs are not well documented in the WVS. The USACE has not undertaken adequate surveys to identify specific locations and currently there are no TCPs or HPRCSITs recorded within the WVS. Given the long history of Kalapuya and Molalla people inhabiting the WRB it is anticipated that there are many places in the WVS that are culturally important to local tribes. The tribes have diverse and substantial interests in the health and wellbeing of the WVS and maintain strong connections to the landscape and resources currently managed by the Corps. This includes all facets of natural and cultural resources. For physical locations, where animals, plants, water, and cultural resources are present, it is reasonable to assume that actions that improve habitat and water quality are beneficial to TCPs and HPRSCITs. Those same actions may erode or expose archaeological resources resulting in an adverse effect to this particular characteristic of a TCP and HPRSCIT. Due to these major data gaps, it is beyond the scope of this analysis to consider the tradeoffs that impact this category of resource and to assess effects.

#### *3.21.2.2 Effects to Cultural Resources Across Alternatives*

**All comparisons of effects for each action alternative are in comparison to the NAA unless stated otherwise.**

##### *3.21.2.2.1 Archaeological Sites*

All of the alternatives would have major adverse effects to cultural resources. This is mainly due to the high number of archaeological resources present in or adjacent to the reservoirs that would be exposed to the annual draft and fill cycle that occurs at the WVS. This draft and fill cycle has occurred for much of the 50 to 80-year existence of the dams and reservoirs, and the effects of the annual cycle of draft and fill has resulted in smaller seasonal impacts that have incrementally built upon the damage of prior years and irreversibly impacted the integrity of archaeological sites that are present in the reservoir. Of the 461 documented archaeological resources, 369 (80%) would be impacted by this draft and fill cycle. This adverse, long-term, and irreversible effect to archaeological resources is considered the baseline and would occur with the NAA and is common to all of the alternatives.

In Table 3.21-10 greatly increased and major adverse impacts related to erosion and exposure of archaeological sites, that would occur as a result of Measures 40 (deeper fall drawdown to regulating outlets) and Measure 720 (spring reservoir drawdown), are noted by project and alternative. These measures drive noticeable increases in erosion and exposure, by drafting deeply and quickly to lower regulating outlets, extending the length of reservoir bed exposure outside of storage season, accelerated erosion due to oversaturated unstable topography, and increasing the number of draft and fill cycles that occur in one water year. Alternatives 3A and 3B would be the most detrimental to archaeological resources due to the high number of projects that would use these deep drawdown measures (n=7 and 54% of the reservoirs). Alternative 2B and Alternative 5 would be less impactful with the proposed use of these measures at three reservoirs (23% of reservoirs impacted), followed by Alternative 2A, which proposes the use of such actions at two projects (15% of reservoirs impacted). The NAA, Alternative 1, and Alternative 4 would have the least increase in impact to archaeological sites, because the drawdown measures would occur only at one reservoir, Fall Creek (8% of reservoirs impacted).

**Table 3.21-10. Major Adverse Effects to Archaeological Sites by Reservoir beyond Draft and Fill Annual Cycle under All Alternatives**

| Project | NAA | Alt 1 | Alt 2A | Alt 2B | Alt 3A | Alt 3B | Alt 4 | Alt 5 |
|---|---|---|---|---|---|---|---|---|
| Fern Ridge | No | No | No | No | No | No | No | No |
| Cottage Grove | No | No | No | No | No | No | No | No |
| Dorena | No | No | No | No | No | No | No | No |
| Dexter | No | No | No | No | No | No | No | No |
| Lookout Point | No | No | No | No | Yes | Yes | No | No |
| Fall Creek | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Hills Creek | No | No | No | No | Yes | Yes | No | No |
| Cougar | No | No | No | Yes | Yes | Yes | No | Yes |
| Blue River | No | No | No | No | Yes | Yes | No | No |
| Foster | No | No | No | No | No | No | No | No |
| Green Peter | No | No | Yes | Yes | Yes | Yes | No | Yes |
| Big Cliff | No | No | No | No | No | No | No | No |
| Detroit | No | No | No | No | Yes | Yes | No | No |
| Total WVS Reservoirs | 1 (8%) | 1 (8%) | 2 (15%) | 3 (23%) | 7 (54%) | 7 (54%) | 1 (8%) | 3 (23%) |

Because these actions occur on such a large scale (per reservoir), these measures cause at least one additional event in a given water year that would have major adverse impact to 80% of archaeological resources. While these effects are not directly measurable (e.g. by observed rate of erosion), it is useful to understand the increased adverse impacts on an order of magnitude. For the alternatives that have two or three reservoirs that would experience spring and/or fall deep drawdowns, this is a 100%-200% increase from the NAA in the number of reservoirs where this measure that would have major adverse effects to archaeological resources (Alternatives 2A, 2B, and 5). For Alternatives 3A and 3B, the use of the deep drawdown measures, would increase the number of reservoirs where major adverse effects would occur to archaeological sites to 600% greater than the NAA, Alternative 1, and Alternative 4.

Through use of GIS and ResSim outputs, one aspect of potential impact to archaeological sites, extent of archaeological site exposure, expressed in acre-days, was modeled for all of the alternatives. Table 3.21-11 shows the results over the course of one water year for the eleven reservoirs that would have reservoir elevation changes (Big Cliff and Dexter are reregulating dams and maintain year round high water elevations), whereas Table 3.21-12 shows the percent change by project and then WVS across the alternatives. In each alternative, all of the eleven reservoirs follow a rule curve that results in one major cycle of draft and fill per water year and several of the measures result in reservoir elevation change. Exposure, as a result of any reservoir elevation change, would impact the 369 (80%) archaeological sites that are adjacent to or within the WVS reservoirs.

The NAA results in 164,109 acre-days of exposure, and only Alternative 1 results in a lower acre-day exposure amount (158,734 acre-days, a 3% decrease in exposure) (Table 3.21-11 and 3.21-12). Most of the alternatives would result in 3%-4% higher exposures rates including Alternatives 2A, Alternative 2B, Alternative 4, and Alternative 5. As noted with prior discussion, Alternative 3A and 3B would be highly detrimental to archaeological resources, and for this particular analysis, would result in markedly higher rates of site exposure (31%-44%).

**Table 3.21-11. Effects to Archaeological Resources through Exposure by Reservoir and Alternative (expressed as acre-day)**

| Reservoir | NAA | Alt 1 | Alt 2A | Alt 2B | Alt 3A | Alt 3B | Alt 4 | Alt 5 |
|---|---|---|---|---|---|---|---|---|
| Detroit | 25,768 | 24,267 | 27,272 | 27,271 | 48,013 | 29,059 | 27,298 | 27,292 |
| Green Peter | 26,068 | 22,060 | 30,240 | 30,240 | 30,240 | 52,148 | 30,406 | 30,202 |
| Foster | 2,551 | 2,551 | 2,532 | 2,532 | 2,532 | 3,516 | 2,551 | 2,533 |
| Blue River | 895 | 872 | 857 | 870 | 926 | 926 | 856 | 883 |
| Cougar | 1,727 | 1,632 | 1,677 | 2,116 | 2,112 | 2,115 | 1,677 | 2,116 |
| Fall Creek | 34,373 | 34,371 | 34,174 | 34,220 | 34,336 | 34,439 | 34,173 | 34,277 |
| Hills Creek | 14,123 | 12,384 | 12,404 | 12,824 | 15,992 | 25,396 | 12,402 | 13,620 |
| Lookout Point | 25,149 | 27,217 | 25,917 | 26,586 | 67,870 | 33,462 | 25,874 | 26,693 |
| Dorena | 4,344 | 4,315 | 4,332 | 4,342 | 4,350 | 4,373 | 4,363 | 4,346 |
| Cottage Grove | 7,242 | 7,195 | 7,170 | 7,189 | 7,324 | 7,249 | 7,184 | 7,209 |
| Fern Ridge | 21,868 | 21,869 | 21,869 | 21,869 | 21,869 | 21,869 | 21,869 | 21,869 |
| Total WVS Acre-Day | 164,109 | 158,734 | 168,445 | 170,060 | 235,564 | 214,552 | 168,652 | 171,039 |

**Table 3.21-12. Effects to Archaeological Resources by Percent Change in Exposure of Archaeological Resources by Reservoir and Alternative**

| Reservoir | Alt 1 | Alt 2A | Alt 2B | Alt 3A | Alt 3B | Alt 4 | Alt 5 |
|---|---|---|---|---|---|---|---|
| Detroit | -6% | 6% | 6% | 86% | 13% | 6% | 6% |
| Green Peter | -15% | 16% | 16% | 16% | 100% | 17% | 16% |
| Foster | 0% | -1% | -1% | -1% | 38% | 0% | -1% |
| Blue River | -3% | -4% | -3% | 3% | 3% | -4% | -1% |
| Cougar | -6% | -3% | 22% | 22% | 22% | -3% | 22% |
| Fall Creek | 0% | -1% | 0% | 0% | 0% | -1% | 0% |
| Hills Creek | -12% | -12% | -9% | 13% | 80% | -12% | -4% |
| Lookout Point | 8% | 3% | 6% | 170% | 33% | 3% | 6% |
| Dorena | -1% | 0% | 0% | 0% | 1% | 0% | 0% |
| Cottage Grove | -1% | -1% | -1% | 1% | 0% | -1% | 0% |
| Fern Ridge | 0% | 0% | 0% | 0% | 0% | 0% | 0% |

| Reservoir | Alt 1 | Alt 2A | Alt 2B | Alt 3A | Alt 3B | Alt 4 | Alt 5 |
|---|---|---|---|---|---|---|---|
| Total WVS Percent Change | -3% | 3% | 4% | 44% | 31% | 3% | 4% |

##### 3.21.2.2.2 Built Resources

In Table 3.21-13, moderate to major adverse effects to built resources are noted by project and alternative. Effects to built resources are high in all of the alternatives (54-31%) with the exception of the NAA, which does not propose any structural measures. Given that the NAA does not propose any structural modifications, and all other alternatives do, any of the proposed structural modifications results in a 100% increase in modification to built resources (any increase from zero results in a 100% increase regardless of the amount). However, the amount of proposed modification varies across alternatives. Alternative 1 proposes the most structural measure that would have moderate to major effects to built resources, followed by Alternative 2A, Alternative 2B, and Alternative 4. Alterative 3A and Alternative 3B have the least structural measures that would have moderate to major effects to the historic WVS. Alternatives that propose structural measures to address upstream and downstream fish passage tend to have less negative effects to archaeological resources in the reservoirs, as opposed to alternatives that propose operations measures to accomplish the same goals.

**Table 3.21-13. Moderate to Major Adverse Effects to Built Resources under All Alternatives**

| Project | NAA | Alt 1 | Alt 2A | Alt 2B | Alt 3A | Alt 3B | Alt 4 | Alt 5 |
|---|---|---|---|---|---|---|---|---|
| Fern Ridge | No | Yes | No | No | No | No | No | No |
| Cottage Grove | No | No | No | No | No | No | No | No |
| Dorena | No | No | No | No | No | No | No | No |
| Dexter | No | Yes | Yes | Yes | No | No | Yes | Yes |
| Lookout Point | No | Yes | Yes | Yes | No | No | Yes | Yes |
| Fall Creek | No | No | No | No | No | No | No | No |
| Hills Creek | No | No | No | No | Yes | Yes | Yes | No |
| Cougar | No | No | Yes | Yes | Yes | Yes | Yes | Yes |
| Blue River | No | No | No | No | Yes | Yes | No | No |
| Foster | No | Yes | Yes | Yes | No | No | Yes | Yes |
| Green Peter | No | Yes | Yes | Yes | Yes | Yes | No | Yes |
| Big Cliff | No | No | No | No | No | No | Yes | No |
| Detroit | No | Yes | Yes | Yes | No | No | Yes | Yes |
| Total WVS Projects | 0 (0%) | 6 (46%) | 6 (46%) | 6 (46%) | 4 (31%) | 4 (31%) | 7 (54%) | 6 (46%) |

**Mitigating Adverse Effects to Cultural Resources**

The annual draft and fill cycle of the WVS that is common across all alternatives has cyclical and incremental permanent major adverse effects to 80% of documented archaeological sites that are present in the WVS. The spring and/or fall deep drawdowns are another set of activities that are adverse to archaeological resources in reservoirs and accelerates the erosion and exposure caused by the annual draft and fill cycle. Across all alternatives, a deep drawdown would occur at one or more reservoirs, though the locations and timing varies. For built resources, moderate to major long term adverse effects would occur to between 31% and 54% of WVS historic districts across all alternatives with the exception of the NAA. The NAA does not include any structural measures that would modify the WVS historic districts.

In general, the scale of long term and permanent adverse impacts to archaeological sites and built resources, is major and requires thoughtful consideration as to how the Corps can manage and mitigate these reservoir-wide and system-wide effects with regard to site protection against erosion and exposure, looting prevention programs, promoting tribal access to these locations, maintaining the important attributes of the WVS historic districts, and educating the public about the importance of cultural resources, local history, tribal sovereignty, and the impacts of looting. The Corps intends to continue to work with federal, state, and tribal partners and other interested parties to identify appropriate management and mitigation strategies that would occur through the proposed action like monitoring of these sites.

As discussed in the introduction of Section 3.21, one avenue currently exists with the development of the historic properties management plan that will act as a companion document to the WVS operations and maintenance NHPA Section 106 programmatic agreement. The Corps will work with Cooperators and tribal partners to identify other opportunities to collaborate on the management of WVS cultural resources.

### *3.21.2.3 No Action Alternative*

The No Action Alternative (NAA) maintains a rule curve that begins drafting in fall to low water levels through the winter, with fill beginning in late winter through the spring, with the highest reservoir level to be reached by the start of summer. This level is maintained through early fall when drafting begins again. This annual draft and fill cycle is a major erosion event for archaeological sites that exist in all of the reservoirs except Big Cliff and Dexter. Both are drawn reregulating dams that maintain high reservoir elevations (though they have been infrequently drawn down in the past and have been subject to increased erosion and exposure during these events). The WVS archaeological resources have been experiencing this cyclical inundation and exposure for five to eight decades depending on the reservoir. This has resulted in noticeable erosion and exposure damage to all resources that are known to be present in the reservoirs. Of the 461 archaeological sites documented at the WVS, 369 (80%) are located in or adjacent to reservoir environments. In the NAA, deep fall drawdowns, which accelerate erosion to landforms and archaeological sites, occur at Fall Creek or 8% of the WVS projects. The NAA would result in 164,109 acre-days of archaeological site exposure across all 11 reservoirs that would experience elevation change.

The public consistently recreates at the reservoirs when water levels are low, and it is a common pastime to collect artifacts at the WVS. The cycle of erosion and exposure is well known, and law enforcement officers increase patrols of reservoirs after a heavy rainfall specifically because the rains would have washed away more soils and exposed artifacts. Unauthorized collection has been documented at all of the 13 projects of the WVS. This is an adverse effect to cultural resources.

No new construction or modification to the 13 historic districts is considered under the NAA, and therefore is not anticipated to have adverse effects to the historic WVS.

The overall effect from the No Action Alternative to Cultural Resources would impact more than 10% of all known cultural resources and would be irreversible, adverse, and major within the WVS. Given that the effects are irreversible, the duration is permanent, and the extent of these impacts is system-wide.

##### *3.21.2.3.1 Climate Change*

Climate change would continue to increase impacts to cultural resources under the NAA due to more winter rainfall that erodes exposed reservoir beds and exposes archaeological materials for the public to illicitly collect artifacts. The warmer weather in the summer and limited water would also expose sites higher in the elevation pools that would allow people to access and illicitly collect from those sites. However, active erosion would not be occurring in the summer months, so it would limit the public's ability to disturb archaeological materials without active digging and vandalism of archaeological sites.

It is anticipated that archaeological resources would continue to steadily degrade if existing draft and fill operations continue. Within 30 years, it is probable that the majority of the sites that are present in the reservoir would be mostly or completely eroded and picked over from unauthorized collection. The limited test excavations recently conducted at archaeological sites at five of the reservoirs indicate that there are little to no intact subsurface components where there are surface expressions of artifacts (at least with this sample). Recent site condition assessments that now span more than one year and one cycle of draft and fill provide further evidence that sites are being actively eroded and looted each water year. Effects to built resources as a result of climate change are not anticipated.

#### ***3.21.2.4 Alternative 1 – Project Storage Alternative***

Like the NAA, Alterative 1 follows a rule curve that results in one major cycle of draft and fill per water year. Alternative 1 would reduce minimum flows to Congressionally authorized minimum flow requirements (#723) at all of the reservoirs except Dexter, Foster, and Big Cliff. This measure would likely have minor short-term benefits to archaeological resources on a system wide level since it would allow for more water storage and a higher likelihood of following the rule curve in a consistent pattern. This is supported by the systemwide 3% decrease in acre-days of site exposure between the NAA (164,109 acre-days) and Alternative 1 (158,734 acre-days). Alternative 1 is the only alternative that posits the use of Measure 723, and it is the only

Alternative that shows minor beneficial changes at the system-level to cultural resources. Several of the reservoirs would have decreased site exposure including Detroit (-6%), Green Peter (-15%), Blue River (-3%), Cougar (-6%), Hills Creek (-12%), Dorena (-1%), and Cottage Grove (-1%). Site exposure at Fall Creek, Fern Ridge, and Foster would not change from the NAA (0% change) whereas Lookout Point would see an 8% increase in exposure days with Alternative 1.

Like the NAA, deep fall drawdowns at Fall Creek would accelerate erosion to landforms and archaeological sites when compared to other reservoirs where deep drawdowns do not occur. As with the NAA, the WVS cycle of draft and fill would continue to adversely affect 369 (80%) of the archaeological sites present, though to a lesser extent when considering site exposure.

Alternative 1 has the potential to cause moderate to major adverse long-term effects to six of the 13 historic districts (46%) because several of the measures propose substantial modifications to the infrastructure of the historic districts. See Table 3.21-14 for corresponding structural measures and the level of effect to built resources that support water quality, downstream and upstream fish passage. Any measures that require construction or modification of infrastructure have the potential to cause effects to archaeological sites through ground disturbance and staging of equipment or short-term reservoir elevation changes that will cause erosion and exposure.

**Table 3.21-14. Level of Adverse Effect to Built Resources under Alternative 1**

| Project | Negligible to Minor Adverse Effects | Minor to Moderate Adverse Effects | Moderate to Major Adverse Effects |
|---|---|---|---|
| Fern Ridge | N/A | N/A | Yes (Measure 52, 639) |
| Cottage Grove | N/A | N/A | N/A |
| Dorena | N/A | N/A | N/A |
| Dexter | Yes (Measure 174) | N/A | Yes (Measure 392, 722) |
| Lookout Point | Yes (Measure 174) | N/A | Yes (Measure 105, 392) |
| Fall Creek | N/A | N/A | N/A |
| Hills Creek | N/A | N/A | N/A |
| Cougar | Yes (Measure 174) | N/A | N/A |
| Blue River | N/A | N/A | N/A |
| Foster | Yes (Measure 174, 479) | N/A | Yes (Measure 392) |
| Green Peter | Yes (Measure 174) | N/A | Yes (Measure 52, 105, 392, 722) |
| Big Cliff | Yes (Measure 174) | N/A | N/A |
| Detroit | Yes (Measure 174) | N/A | Yes (Measure 105, 392) |

The overall effect from Alternative 1 to Cultural Resources would impact more than 10% of all known cultural resources and would be irreversible, adverse, and major within the WVS. Given that the effects are irreversible, the duration is permanent, and the extent of these impacts is system-wide

##### *3.21.2.4.1 Climate Change*

Climate Change impacts are assumed to be similar to those described for the NAA, with the exception that the use of Measure 723 as opposed to the 2008 BiOp target flows that are currently in use would result in retaining more water at the reservoirs and potentially reduce shifts in reservoir elevations that can affect archaeological resources. This beneficial effect is negligible/minor due to the inability to fully measure it, but the 3% decrease in site exposure that is estimated for Alternative 1 may indicate continued slight benefits if the system is maintained this way through continued climate change. Effects to built resources as a result of climate change are not anticipated.

#### ***3.21.2.5 Alternative 2A – Hybrid Alternative***

Like the NAA and Alterative 1, Alternative 2A follows a rule curve that results in one major cycle of draft and fill per water year. Alternative 2A proposes a deeper fall reservoir drawdown (#40) at Green Peter (780 feet) and Fall Creek as opposed to just Fall Creek (with the NAA and Alternative 1). A deep fall drawdown would increase erosion at Green Peter and Fall Creek reservoirs, but the adverse effect to documented archaeological sites is not fully measurable. On a qualitative level, it is known that deep drawdowns increase erosion because soils are not allowed to properly drain before they are exposed, and this increases the vulnerability of present sites. The number of reservoirs impacted on a project level doubles in this Alternative and results in a higher number of documented archaeological sites that would be subject to this increased erosion. In all three alternatives, the WVS cycle of draft and fill would continue to adversely affect 369 (80%) of documented archaeological sites.

Alternative 2A proposes implementing an integrated temperature and habitat flow regime (#30a) rather that adhering to either the 2008 BiOp target flows or the minimum flows to Congressionally authorized minimum flow. This flow regime may minimally affect reservoir elevations, and therefore, would result in a negligible/minor adverse effect to archaeological sites. This is supported by a minor systemwide increase in acre-days of site exposure from the NAA (3%). By project, however, several of the reservoirs would see decreased acre-days of site exposure including Foster (-1%), Blue River (-4%), Cougar (-3%), Fall Creek (-1%), and Cottage Grove (-1%). Dorena and Fern Ridge would not have any changes from the NAA (0%). Major adverse effects and increased site exposure at the local level would occur at Detroit (6%), Green Peter (16%) and Lookout Point (3%) while major beneficial reduction of exposure would occur at Hills Creek (-12%).

Alternative 2A has the potential to cause moderate to major effects to six of the 13 historic districts (46%). See Table 3.21-15 for corresponding measures that support water quality, downstream and upstream fish passage.

**Table 3.21-15. Level of Adverse Effect to Built Resources under Alternative 2A**

| Project | Negligible to Minor Adverse Effects | Minor to Moderate Adverse Effects | Moderate to Major Adverse Effects |
|---|---|---|---|
| Fern Ridge | N/A | N/A | N/A |
| Cottage Grove | N/A | N/A | N/A |
| Dorena | N/A | N/A | N/A |
| Dexter | N/A | N/A | Yes (Measure 52, 722) |
| Lookout Point | N/A | N/A | Yes (Measure 392) |
| Fall Creek | N/A | N/A | N/A |
| Hills Creek | N/A | N/A | N/A |
| Cougar* | N/A | N/A | Yes (Measure 392, 52) |
| Blue River | N/A | N/A | N/A |
| Foster | Yes (Measure 479) | N/A | Yes (Measure 392) |
| Green Peter | N/A | N/A | Yes (Measure 52, 722) |
| Big Cliff | N/A | N/A | N/A |
| Detroit | N/A | N/A | Yes (Measure 105, 392) |

*2A proposes construction of a downstream passage structure to support downstream fish passage at Cougar, whereas 2B uses deep drawdowns in fall and spring.

The overall effect from the Alternative 2A to Cultural Resources would impact more than 10% of all known cultural resources and would be irreversible, adverse, and major within the WVS. Given that the effects are irreversible, the duration is permanent, and the extent of these impacts is system-wide.

#### *3.21.2.5.1 Near-term operations Measures*

The discussion of the near-term operations measures can be found in Chapter 2. The following considers the impacts of the near-term operations measures on cultural resources.

Operations that focus on deep drawdowns, earlier drawdown, and delayed refills for downstream fish passage would greatly increase the erosion and exposure of archaeological sites at the reservoir level and would have moderate to major adverse effects. Drafting deeply and quickly to the lower regulating outlets would accelerate landform and archaeological site erosion due to oversaturated unstable topography throughout the reservoir, and the delayed fills and early drawdowns would extend the length that most of the reservoir bed is exposed outside of the storage season (see Table 3.21-16). Other operational measures that focus on spring spills for downstream fish passage do result in elevation changes, but to a lesser extent. The elevation changes for spill operations would occur during planned fill, when reservoir levels are already increasing, and low elevation sites are already inundated. These planned fills would be controlled and would be kept at steady elevations as much as possible, resulting in infrequent or short-lived fluctuations in water elevation (which could increase site erosion within a narrow elevation range). As a result, less of the reservoir and fewer sites would be adversely affected than when the deep drawdowns and delayed refills occurred.

Operations that have the reservoir-level and more localized adverse effects would occur at four, or 31%, of the WVS reservoirs including Green Peter, Foster, Cougar, and Lookout Point. The adverse effects of these measures are major, permanent, and irreversible. It is anticipated that archaeological resources would continue to steadily degrade with the routine draft and fill operations, and the adverse effects would be accelerated by the deep drawdowns, early drawdowns, and delayed refills at Green Peter, Foster, Cougar, and Lookout Point. Within 15 years, it is probable that the majority of the sites that are present in the four reservoirs would be mostly or completely eroded and picked over from unauthorized collection.

**Table 3.21-16. Operations that Would Cause Adverse Effects to Archaeological Sites**

| Project | Operation | Reservoir Elevation Change? | Deep Drawdown? |
|---|---|---|---|
| Green Peter | Utilize spillway for improved downstream fish passage in the spring; perform spill operation until 01 May or for 30 days, whichever is longer | Yes | No |
| Green Peter | Deep drawdown and RO prioritization for improved downstream fish passage | Yes | Yes |
| Foster | Earlier fall drawdown, reach 620-625 feet by Oct. 1 | Yes | No |
| Foster | Delay refill and utilize spillway in the spring for improved downstream fish passage | Yes | No |
| Cougar | Deep drawdown and RO prioritization for improved downstream fish passage | Yes | Yes |
| Cougar | Delayed reservoir refill and RO prioritization for improved downstream fish passage | Yes | No |
| Lookout Point | Deep drawdown and RO prioritization for improved downstream fish passage | Yes | Yes |
| Lookout Point | Utilize spillway for improved downstream fish passage in the spring | Yes | No |

*Some aspects of this operation would not have adverse effects to archaeological sites.

In Table 3.21-17, the operations that would cause negligible adverse effects to archaeological sites are listed. While these actions in themselves won't increase erosion and exposure of archaeological sites, these operations are coupled with other aspects that do have moderate to major adverse effects including deep drawdown, delayed refill, early refill, and spring spill at three of the reservoirs including Green Peter, Foster, and Lookout Point. The measures at Hills Creek and Detroit would not be paired with adverse actions.

**Table 3.21-17. Operations that Would Cause No/Negligible Effects to Archaeological Sites**

| Project | Operation |
|---|---|
| Hills Creek | Nighttime RO prioritization for improved downstream fish passage (downstream fish passage) |
| Detroit | Spring downstream fish passage and operational downstream temperature management |
| Detroit | Nighttime RO prioritization for improved downstream fish passage |
| Detroit | Spread spill across spillbays to reduce downstream TDG exceedances |
| Green Peter | Outplanting plan for the reintroduction of adult Chinook salmon above Green Peter Dam |
| Foster | After Oct 1, utilize the spillway for improved downstream fish passage in the fall |
| Foster | Use the fish weir in the summer for improved downstream temperature management and upstream fish migration/passage |
| Lookout Point | RO use in the fall for downstream temperature management |

*Some aspects of this measure would have adverse effects to archaeological sites.

None of the near-term operations are structural, and therefore, would have no effect to the built resources of the WVS.

##### *3.21.2.5.2 Climate Change*

Climate change impacts are not anticipated to be substantially different than those discussed for the NAA and Alternative 1. With integrated temperature and habitat flow regimes, it is anticipated that reservoir elevations may fluctuate to meet these flow targets with increasingly hotter and drier summers.

Over the life of the project (30 years), archaeological resources would be impacted to a similar degree as that described in the NAA and Alternative 1. Effects to built resources as a result of climate change are not anticipated.

#### *3.21.2.6 Alternative 2B -- Hybrid Alternative*

Alterative 2B as well as the NAA, Alternative 1, and Alternative 2A follows a rule curve that results in one major cycle of draft and fill per water year. Alternative 2B diverges from the other alternatives by proposing a deep spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40) at Cougar (1330 feet), but like Alternative 2A proposes a fall deep drawdown at Green Peter (780 feet) and, like the NAA, Alternative 1, and Alternative 2A, at Fall Creek. Alternative 2B proposes structural measures at Lookout Point, Foster, and Detroit to facilitate downstream fish passage. This differs from Alternative 2A, which includes structural measures at Lookout Point, Foster, Detroit, and Cougar.

Like the other reservoirs where deep drawdowns would occur, portions of Cougar Reservoir is very steeply sloped and experiences several forms of sheet erosion and mass wasting events during routine drafting. It is anticipated that a deep drawdown in the fall and spring would have major impacts to reservoir slope stability and the archaeological sites present. Again, this is not a measurable impact, but a qualitative assessment of increased vulnerability of archaeological sites that would occur during multiple deep drawdowns. It is measurable, however, that Cougar Reservoir would experience two cycles of draft and fill in one water year, doubling impacts from this already negatively impactful action.

Alternative 2B would increase the number of reservoirs that experience deep drawdowns (up to three, from one or two with the NAA, Alternative 1 and Alternative 2A). Alternative 2B would also majorly lengthen the amount of time that sites at Cougar (22%) and Green Peter (16%) would be exposed to human-induced impacts. Both reservoirs experiences high volumes of recreationalists when the roads are passable and not snowed it, and it is anticipated that unauthorized artifact collection would increase during peak recreation season. In all three alternatives, the WVS cycle of draft and fill would continue to adversely affect 369 (80%) of documented archaeological sites, but adverse effects specifically to archaeological sites at Cougar and Green Peter are increased. Lookout Point and Detroit would also see moderate adverse effects with increase site exposure from the NAA (6%).

Overall, the WVS would see a 4% system-wide increase in site exposure with Alternative 2B. The remaining reservoirs would see decreased or no change to site exposure including Foster (-1%), Blue River (-3%), Fall Creek (0%), Hills Creek (-9%), Dorena (0%), Cottage Grove (-1%), and Fern Ridge (0%).

Alternative 2B has the potential to cause moderate to major effects to six of the 13 historic districts (46%). See Table 3.21-18 for corresponding measures that support water quality, downstream and upstream fish passage.

**Table 3.21-18. Level of Adverse Effect to Built Resources under Alternative 2B**

| Project | Negligible to Minor Adverse Effects | Minor to Moderate Adverse Effects | Moderate to Major Adverse Effects |
|---|---|---|---|
| Fern Ridge | N/A | N/A | N/A |
| Cottage Grove | N/A | N/A | N/A |
| Dorena | N/A | N/A | N/A |
| Dexter | N/A | N/A | Yes (Measure 52, 722) |
| Lookout Point | N/A | N/A | Yes (Measure 392) |
| Fall Creek | N/A | N/A | N/A |
| Hills Creek | N/A | N/A | N/A |
| Cougar* | N/A | N/A | Yes (Measure 52) |
| Blue River | N/A | N/A | N/A |

| Project | Negligible to Minor Adverse Effects | Minor to Moderate Adverse Effects | Moderate to Major Adverse Effects |
|---|---|---|---|
| Foster | Yes (Measure 479) | N/A | Yes (Measure 392) |
| Green Peter | N/A | N/A | Yes (Measure 52, 722) |
| Big Cliff | N/A | N/A | N/A |
| Detroit | N/A | N/A | Yes (Measure 105, 392) |

*2B uses deep drawdowns in fall and spring to support downstream fish passage at Cougar, whereas 2A proposes construction of a downstream passage structure.

The overall effect from Alternative 2B to Cultural Resources would impact more than 10% of all known cultural resources and would be irreversible, adverse, and major within the WVS. Given that the effects are irreversible, the duration is permanent, and the extent of these impacts is system-wide

#### *3.21.2.6.1 Climate Change*

Climate Change impacts anticipated with Alternative 2B continue to be similar to the NAA, Alternative 1, and Alternative 2A. Over the life of the project (30 years), archaeological sites in the reservoirs would continue to degrade, though resources at Fall Creek, Cougar, and Green Peter would likely degrade from erosion and exposure at an accelerated rate. Cougar would have even more erosion as it experiences two draft and fill cycles within a given water year. Effects to built resources as a result of climate change are not anticipated.

#### *3.21.2.6.2 Near-Term Operations Measures*

See Section 3.21.3.3.1.

### ***3.21.2.7 Alternative 3A – Operations-Focused Fish Passage Alternative***

Alterative 3A deviates strongly from the NAA as well as Alternative 1, Alternative 2A, and Alternative 2B in regard to the increase in potential adverse impacts to archaeological resources. Deeper fall reservoir drawdowns (#40) are proposed for seven reservoirs including Fall Creek, Blue River (1165 feet), Hills Creek (1446 feet), Green Peter (780 feet), Detroit (1375 feet), Lookout Point (761 feet), and Cougar (1517 feet). Spring reservoir drawdowns (#720) are proposed at three of those reservoirs including Detroit, Lookout Point, and Cougar (to the same elevations).

At all of these reservoirs, accelerated erosion would impact slope stability and the archaeological sites present, but at a much larger scale. Over 50% of reservoirs and associated archaeological sites would be vulnerable to increased erosion from the fall deep drawdowns, and nearly 25% of reservoirs would experience additional erosion by doubling the cycle of draft and fill that occur in one water year. Alternative 3A would result in a 600% increase in this majorly adverse action when compared to the NAA.

Alternative 3A would also greatly lengthen the amount of time that sites at Detroit, Lookout Point, Cougar, Green Peter, and Hills Creek reservoirs would be exposed to human-induced impacts. All of these reservoirs have high volumes of recreation and known looting issues. It is anticipated that unauthorized artifact collection would increase in the spring and fall due to the 86% increase in site exposure at Detroit, 170% increase at Lookout Point, 22% increase at Cougar, 16% increase at Green Peter, and 13% increase at Hills Creek. Blue River (3% increase) and Fall Creek (0% increase) would still be subject to high levels of erosion and site exposure during the proposed fall drawdowns though the change in site exposure between the NAA and Alternative 3A is minor to negligible at these reservoirs. Like all of the preceding alternatives, the WVS cycle of draft and fill would continue to adversely affect 369 (80%) of documented archaeological sites. Unique to Alternative 3A, the WVS would experience a 44% increase in site exposure from the NAA. Adverse effects specifically to archaeological sites at seven reservoirs would be substantially high.

Alternative 3A has the potential to cause moderate to major effects to four of the 13 historic districts (31%). See Table 3.21-19 for corresponding measures that support water quality, downstream and upstream fish passage.

**Table 3.21-19. Level of Adverse Effect to Built Resources under Alternative 3A**

| Project | Negligible to Minor Adverse Effects | Minor to Moderate Adverse Effects | Moderate to Major Adverse Effects |
|---|---|---|---|
| Fern Ridge | N/A | N/A | N/A |
| Cottage Grove | N/A | N/A | N/A |
| Dorena | N/A | N/A | N/A |
| Dexter | N/A | N/A | N/A |
| Lookout Point | N/A | N/A | N/A |
| Fall Creek | N/A | N/A | N/A |
| Hills Creek | N/A | N/A | Yes (Measure 52, 722) |
| Cougar | N/A | N/A | Yes (Measure 52) |
| Blue River | N/A | N/A | Yes (Measure 52, 722) |
| Foster | Yes (Measure 479) | N/A | N/A |
| Green Peter | N/A | N/A | Yes (Measure 52, 722) |
| Big Cliff | N/A | N/A | N/A |
| Detroit | N/A | N/A | N/A |

The overall effect from Alternative 3A to Cultural Resources would impact more than 10% of all known cultural resources and would be irreversible, adverse, and major within the WVS. Given that the effects are irreversible, the duration is permanent, and the extent of these impacts is system-wide.

##### *3.21.2.7.1 Climate Change*

Climate Change would further exacerbate adverse effects to archaeological resources under Alternative 3A, specifically at the seven reservoirs that would experience spring and/or fall deep drawdown. Low reservoir elevations in the spring, would likely continue into summer resulting in exposed and accessible reservoir beds. If target summer elevations can be met, deep fall drawdowns would impact vulnerable slopes and give way to heavy winter rains that continue to erode and degrade reservoir landforms and archaeological sites.

Over the life of the project (30 years), it is anticipated that archaeological sites may be entirely eroded from the seven reservoirs that experience deep drawdowns. At the three that would have spring and fall deep drawdowns, and would have double the draft and fill cycle, archaeological resources may be fully eroded within 10-15 years. Effects to built resources as a result of climate change are not anticipated.

##### *3.21.2.7.2 Near-Term Operations Measures*

See Section 3.21.3.3.1.

#### ***3.21.2.8 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at COU)***

Alterative 3B shares similarities with 3A, but is quite different from the NAA, Alternative 1, Alternative 2A, and Alternative 2B. Deeper fall reservoir drawdowns (#40) are proposed for the same seven reservoirs including Fall Creek, Blue River (1165 feet), Hills Creek (1446 feet), Green Peter (780 feet), Detroit (1375 feet), Lookout Point (761 feet), and Cougar (1517 feet). Spring reservoir drawdowns (#720), however, are proposed at Hills Creek, Cougar, and Green Peter. In both of these alternatives, Cougar would have a spring and fall deep drawdown. In Alternative 3B, the fall deep drawdown at Cougar would pass through the diversion tunnel.

Like with Alternative 3A, accelerated erosion would impact slope stability and the archaeological sites present in the reservoirs, at a similar scale, but with slightly different locations. Again, more than 50% of reservoirs and associated archaeological sites would be vulnerable to increased erosion from the fall deep drawdowns, and nearly 25% of reservoirs would experience additional erosion by doubling the cycle of draft and fill that occur in one water year. This alternative would result in a 600% increase in this adverse effect.

Alternative 3B would also greatly lengthen the amount of time of site exposure at Detroit (13%), Foster (38%), Hills Creek (80%), Cougar (22%), Lookout Point (170%), and Green Peter (100%) and ultimately exposure to human-induced impacts. All of these reservoirs have high volumes of recreation and known looting issues. It is anticipated that unauthorized artifact collection would increase in the spring and fall. Fall Creek does and would continue to experience illicit collection during the deep fall drawdown (though site exposure would remain unchanged from the NAA), and Blue River would see a minor increase in site exposure days (3%). Cottage Grove and Fern Ridge would not see an increase in site exposure days with

Alternative 3B. As with all alternatives, the WVS cycle of draft and fill would continue to adversely affect 369 (80%) of documented archaeological sites. Unique to Alternative 3B, the WVS would experience a 31% higher site exposure rate than the NAA. Adverse effects specifically to archaeological sites at seven of the reservoirs are substantially high.

Alternative 3B has the potential to cause moderate to major effects to four of the 13 historic districts (31%). See Table 3.21-20 for corresponding measures that support water quality, downstream and upstream fish passage.

**Table 3.21-20. Level of Adverse Effect to Built Resources under Alternative 3B**

| Project | Negligible to Minor Adverse Effects | Minor to Moderate Adverse Effects | Moderate to Major Adverse Effects |
|---|---|---|---|
| Fern Ridge | N/A | N/A | N/A |
| Cottage Grove | N/A | N/A | N/A |
| Dorena | N/A | N/A | N/A |
| Dexter | N/A | N/A | N/A |
| Lookout Point | N/A | N/A | N/A |
| Fall Creek | N/A | N/A | N/A |
| Hills Creek | N/A | N/A | Yes (Measure 52, 722) |
| Cougar | N/A | N/A | Yes* |
| Blue River | N/A | N/A | Yes (Measure 52, 722) |
| Foster | Yes (Measure 479) | N/A | N/A |
| Green Peter | N/A | N/A | Yes (Measure 52, 722) |
| Big Cliff | N/A | N/A | N/A |
| Detroit | N/A | N/A | N/A |

*This would result in modification to the existing diversion tunnel that is a contributing element of the Cougar Historic District.

The overall effect from Alternative 3B to Cultural Resources would impact more than 10% of all known cultural resources and would be irreversible, adverse, and major within the WVS. Given that the effects are irreversible, the duration is permanent, and the extent of these impacts is system-wide.

### *3.21.2.8.1 Climate Change*

As with Alternative 3A, climate change would further exacerbate adverse effects to archaeological resources, specifically at the reservoirs that would experience spring and/or fall deep drawdown. Low reservoir elevations in the spring, would likely continue into summer resulting in exposed and accessible reservoir beds. If target summer elevations are met, deep fall drawdowns would impact vulnerable slopes and give way to heavy winter rains that continue to erode and degrade reservoir landforms and archaeological sites.

Over the life of the project (30 years), it is anticipated that archaeological sites may be entirely eroded from the seven reservoirs that experience deep drawdowns. At the three that would have spring and fall deep drawdowns, and would have double the draft and fill cycle, archaeological resources may be fully eroded within 10-15 years. Effects to built resources as a result of climate change are not anticipated.

##### *3.21.2.8.2 Near-Term Operations Measures*

See Section 3.21.3.3.1.

#### ***3.21.2.9 Alternative 4 – Structures-Based Fish Passage Alternative***

Alterative 4 follows a rule curve that results in one major cycle of draft and fill per water year and is similar to Alternative 1 in regard to impacts to archaeological resources. The impacts are also similar to the NAA. Alternative 4, however, does not propose any additional deep drawdowns beyond those at Fall Creek nor does the alternative propose spring spills over the spillway. Rather this alternative focuses heavily on structure-based measures to accomplish downstream fish passage. As with the NAA, the WVS cycle of draft and fill would continue to adversely affect 369 (80%) of the archaeological sites present.

Like Alternative 1, Alternative 4 would result in a minor increase in system-wide site exposure (3% increase from NAA). The most impacted reservoirs include Detroit (6%) and Green Peter (17%). The remaining reservoirs would either see negligible or minor adverse or beneficial changes in site exposure from the NAA: Lookout Point (3%), Foster (0%), Blue River (-4%), Cougar (-3%), Fall Creek (-1%), Dorena (0%), Cottage Grove (-1%), and Fern Ridge (0%). Hills Creek would see a major beneficial decrease in site exposure (-12%).

Alternative 4 has the potential to cause moderate to major effects to seven of the 13 historic districts (54%). See Table 3.21-21 for corresponding measures that support water quality, downstream and upstream fish passage.

**Table 3.21-21. Level of Adverse Effect to Built Resources under Alternative 4**

| Project | Negligible to Minor Adverse Effects | Minor to Moderate Adverse Effects | Moderate to Major Adverse Effects |
|---|---|---|---|
| Fern Ridge | N/A | N/A | N/A |
| Cottage Grove | N/A | N/A | N/A |
| Dorena | N/A | N/A | N/A |
| Dexter | Yes (Measure 174) | N/A | Yes (Measure 392, 722) |
| Lookout Point | Yes (Measure 174) | N/A | Yes (Measure 105, 392) |
| Fall Creek | N/A | N/A | N/A |
| Hills Creek | N/A | N/A | Yes (Measure 105, 392, 722) |
| Cougar | Yes (Measure 174) | N/A | Yes (Measure 392) |

| Project | Negligible to Minor Adverse Effects | Minor to Moderate Adverse Effects | Moderate to Major Adverse Effects |
|---|---|---|---|
| Blue River | N/A | N/A | N/A |
| Foster | Yes (Measure 174, 479) | N/A | Yes (Measure 392) |
| Green Peter | Yes (Measure 174) | N/A | N/A |
| Big Cliff | Yes (Measure 174) | N/A | Yes (Measure 392) |
| Detroit | Yes (Measure 174) | N/A | Yes (Measure 105, 392) |

The overall effect from Alternative 4 to Cultural Resources would impact more than 10% of all known cultural resources and would be irreversible, adverse, and major within the WVS. Given that the effects are irreversible, the duration is permanent, and the extent of these impacts is system-wide.

#### *3.21.2.9.1 Climate Change*

Climate change impacts are assumed to be similar to those described for the NAA and Alternative 1, though flow regimes differ.

Over the life of the project (30 years), it is anticipated that archaeological resources would be impacted to a similar degree as that described in the NAA. Effects to built resources as a result of climate change are not anticipated.

#### *3.21.2.9.2 Near-term operations measures*

See Section 3.21.3.3.1.

### ***3.21.2.10 Alternative 5 – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)***

Alternative 5 is nearly identical to Alternative 2B except that the integrated temperature and habitat flow regime (Measure 30a) has been replaced by the refined integrated temperature and habitat flow regime (Measure 30b).

Alterative 5 as well as the NAA, Alternative 1, Alternative 2A, Alternative 2B, Alternative 3A, Alternative 3B, and Alternative 4 follows a rule curve that results in one major cycle of draft and fill per water year. Alternative 2B and Alternative 5 diverge from the other alternatives by proposing a spring reservoir drawdown (#720) and a deeper fall reservoir drawdown (#40) at Cougar (1330 feet), but like Alternative 2A proposes a deep fall drawdown at Fall Creek and Green Peter (780 feet). Alternative 2B and Alternative 5 propose constructing structural downstream fish passage (#392) at Lookout Point, Foster, and Detroit. This differs from Alternative 2A, which includes structural downstream fish passage at Lookout Point, Foster, Detroit, and Cougar.

Like the Green Peter and Fall Creek reservoirs, where deep drawdowns would occur, portions of Cougar Reservoir are very steeply sloped and experiences several forms of sheet erosion and mass wasting events during routine drafting. It is anticipated that a deep drawdown in the fall and spring at Cougar may have major impacts to reservoir slope stability and the archaeological sites present. Again, this is not a measurable impact, but a qualitative assessment of increased vulnerability of archaeological sites that would occur during multiple deep drawdowns. It is measurable, however, that Cougar Reservoir would experience two cycles of draft and fill in one water year, doubling impacts from this already negatively impactful action.

Alternative 2B and Alternative 5 would increase the number of reservoirs that experience deep drawdowns (up to three, from one or two with the NAA, Alternative 1, and Alternative 2B). Alternative 2B and Alternative 5 would also greatly lengthen the amount of time that sites at Detroit (6%), Green Peter (16%), Cougar Reservoir (22%) and Lookout Point (6%) would be exposed to human-induced impacts. These reservoirs experience high volumes of recreationalists when the roads are passable, and it is anticipated that unauthorized artifact collection would increase during peak recreation season. In all alternatives, the WVS cycle of draft and fill would continue to adversely affect 369 (80%) of documented archaeological sites. Adverse effects specifically to archaeological sites at Cougar, Fall Creek, and Green Peter, however, are substantially high.

Alternative 2B and Alternative 5 have the potential to cause moderate to major effects to six of the 13 historic districts (46%). See Table 3.21-22 for corresponding measures that support water quality, downstream and upstream fish passage.

**Table 3.21-22. Level of Adverse Effect to Built Resources under Alternative 5**

| Project | Negligible to Minor Adverse Effects | Minor to Moderate Adverse Effects | Moderate to Major Adverse Effects |
|---|---|---|---|
| Fern Ridge | N/A | N/A | N/A |
| Cottage Grove | N/A | N/A | N/A |
| Dorena | N/A | N/A | N/A |
| Dexter | N/A | N/A | Yes (Measure 52, 722) |
| Lookout Point | N/A | N/A | Yes (Measure 392) |
| Fall Creek | N/A | N/A | N/A |
| Hills Creek | N/A | N/A | N/A |
| Cougar* | N/A | N/A | Yes (Measure 52) |
| Blue River | N/A | N/A | N/A |
| Foster | Yes (Measure 479) | N/A | Yes (Measure 392) |
| Green Peter | N/A | N/A | Yes (Measure 52, 722) |
| Big Cliff | N/A | N/A | N/A |
| Detroit | N/A | N/A | Yes (Measure 105, 392) |

*2B and 5 use deep drawdowns in fall and spring to support downstream fish passage at Cougar, whereas 2A proposes construction of a downstream passage structure.

The overall effect from Alternative 5 to Cultural Resources would impact more than 10% of all known cultural resources and would be irreversible, adverse, and major within the WVS. Given that the effects are irreversible, the duration is permanent, and the extent of these impacts is system-wide.

###### *3.21.2.10.1 Climate Change*

Climate Change impacts anticipated with Alternative 5 continue to be similar to the NAA, Alternative 1, Alternative 2A, and Alternative 2B. Over the life of the project (30 years), archaeological sites in the reservoirs would continue to degrade, though resources at Fall Creek, Cougar, and Green Peter would likely degrade from erosion and exposure at an accelerated rate. Cougar would have even more erosion as it would experience two draft and fill cycles within a given water year. Effects to built resources as a result of climate change are not anticipated.

###### *3.21.2.10.2 Near- Term Operations Measures*

See Section 2.21.3.3.2.

## 3.22 VISUAL RESOURCES

Visual resources consist of all the features that give a landscape its visually aesthetic qualities. This includes landforms, vegetation, water surfaces, and cultural modifications, or physical changes made by human activities. Landscape features provide viewers with an overall impression of an area; this overall impression can be referred to as the area's "visual character." Visual resources are assessed to determine if a given project would appear to be visually compatible with the established landscape features of an area, or if they would appreciably contrast (Headley 2011). The focus of this section is to assess the visual resources located at the 13 dams and reservoirs within the Willamette Valley System (WVS).

### 3.22.1 Methodology

The Bureau of Land Management (BLM) Visual Resource Management (VRM) system provides a framework for managing visual resources for BLM-administered lands. While the VRM system was developed for application on the public lands managed by BLM, it is a useful tool to assess impacts on other lands as well. The system includes a mechanism for identifying visual resource values, minimizing the impacts of surface-disturbing activities on visual resources, and maintaining the scenic value of tracts of land for the future. The VRM process includes preparing an inventory of scenic values of a landscape (visual resource inventory or VRI), which will be included in this Affected Environment section; and analyzing the inventory (visual resource contrast rating), which will evaluate potential impacts from the Proposed Action and alternatives in the Environmental Effects section (BLM No Date-a).

VRI consists of assessing and rating the intrinsic scenic quality of a particular tract of land through the Scenic Quality Rating process; measuring public concern for the scenic quality of the tract through the Sensitivity Level Analysis; and classifying the distance by which tracts of land are visible from travel routes or observation points. The Scenic Quality Rating is a measure of the visual appeal of a tract of land using key factors. These key factors include physiographic characteristics, such as landforms, vegetation, and water; similar visual patterns, such as texture, color, and light; or areas of similar impact from human-made modifications, such as cultural modifications and scarcity. Each key factor has its own rating criteria based on its qualities and features (e.g., clean and clear water present at a tract of land has a higher rating compared to no water present). The total score translates into the land's scenic quality rating of A, B, or C (most to least scenic). The Sensitivity Level Analysis is a measure of public concern for scenic quality. The landscape being inventoried is assigned high, moderate, or low sensitivity levels by analyzing the various factors of public concern, such as types of users, amount of use, public interest, etc. Lastly, visual resources are categorized based on how visible that tract of land is from travel routes or observation points. The three distance zones include foreground-middleground (visible from highways, rivers, or other viewing locations less than 3 to 5 miles), background (less than 15 miles away), and seldom seen (hidden from view). Based on the results of the VRI, visual resources are assigned one of four classes, with Class I resources having the greatest relative visual values and Class IV resources having the lowest. Each class has established management objectives:

- Class I Objective – Preserve the existing character of the landscape. The level of change to the characteristic landscape should be very low and must not attract attention.
- Class II Objective – Retain the existing character of the landscape. The level of change to the characteristic landscape should be low.
- Class III Objective – Partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate.
- Class IV Objective – Provide for management activities which require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high.

The analysis of the inventory stage of the VRM process, or the visual resources contrast rating, involves comparing features of the Proposed Action and alternatives with major features in the existing landscape to determine whether or not the potential visual impacts would meet the management objectives established for the area, or if design adjustments would be required (BLM No Date-a). This analysis will be included in the Environmental Effects section.

The VRI was developed for those dams and reservoirs whose visual resources could be impacted substantially from the Proposed Action and alternatives, such as new construction or substantial changes to water levels. This includes Lookout Point, Detroit, Green Peter, Hills Creek, Dexter, Cougar, Blue River, Foster, and Fall Creek. The overall results of the VRI (including the Scenic Quality Rating process, Sensitivity Level Analysis, and categorization of distance zones) are presented in 3.22.3 and summarized below for these dams and reservoirs. The more detailed results of the VRI are included in Appendix T. It should be noted that the VRI process is subjective and can vary based on the analyst and the resources available. Careful consideration must be given for every assessment and rating in order to conclude the most accurate inventory of each dam and reservoir. Dams and reservoirs whose visual resources are not expected to be impacted by the Proposed Action and alternatives – including Big Cliff, Dorena, Cottage Grove, and Fern Ridge – are not discussed in this section.

### 3.22.2 Willamette Valley Basin

The Willamette Valley is bound by the Cascade Range to the east, the Coast Range on the west, and the Calapooya Mountains to the south. The river valley extends approximately 187 miles to the north where it flows into the Columbia River (USACE 2019a). The valley consists of nearly level to gently sloping broad alluvial floodplains, scattered low hills, and adjacent mountain foothills (Morlan et al. 2010). While forested land covers approximately 70 percent of the watershed, agricultural land accounts for approximately 22 percent of the basin. Urban land covers approximately 6 percent of the basin and is mostly congregated in the valley along the mainstem of the Willamette River (EPA 2013b).

Since the 1850s, the Willamette Valley has been dramatically altered by agricultural, hydropower, and urban development, which has significantly affected oak woodland, grassland, and wetland habitats (OPRD 2017). Dams, diversions, levees, and similar alterations have largely disconnected the Willamette River and reduced its associated original wetland area by approximately 57 percent (Morlan et al. 2010). Some aesthetic value has been reestablished in the WVS through the creation of parks, recreational reservoirs and beaches, trails, and other scenic viewpoints accessible to the public. In FY 2019, almost two million visitors were recorded within the Willamette Valley Basin, also referred to as the Willamette watershed (USACE 2019u).

As noted above, the VRI was developed for those dams and reservoirs whose visual resources could be impacted substantially from the Proposed Action and alternatives, such as new construction or substantial changes to water levels. As shown below in Figure 3.22-1, these include Lookout Point, Detroit, Green Peter, Hills Creek, Dexter, Cougar, Blue River, Foster, and Fall Creek.

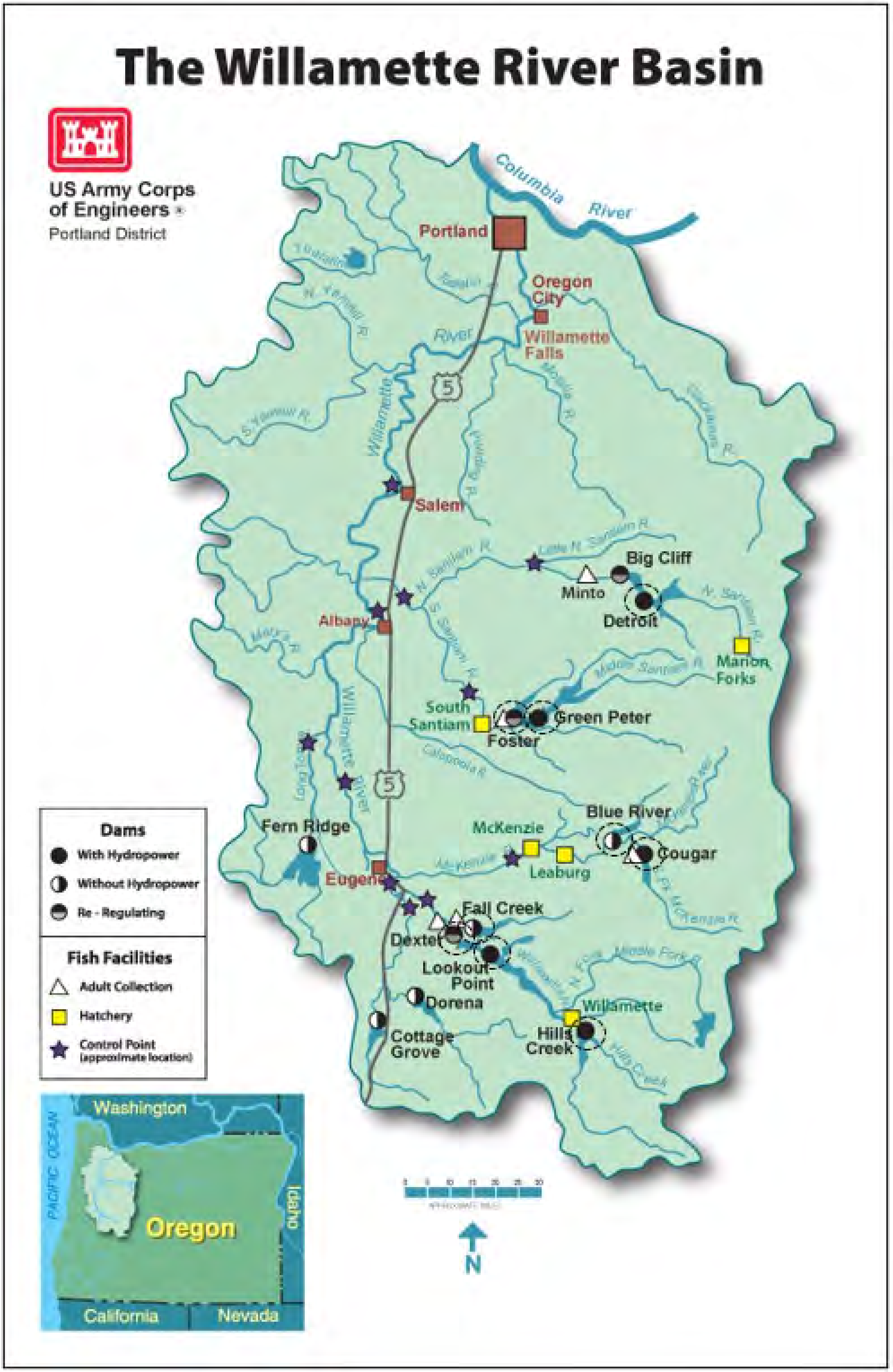


**Figure 3.22-1. Visual Resource Inventory of Dams and Reservoirs in the Willamette River Basin**

### 3.22.3 Visual Resource Inventory of Select Dams and Reservoirs

This section provides the results of the VRI for the nine dams and reservoirs that could be impacted substantially from the Proposed Action and alternatives, including the management class assigned to each dam and reservoir. A more detailed description of how each dam and reservoir was rated in the Scenic Quality Inventory, Sensitivity Level Analysis, and Distance Zones is included in Appendix T. The nine dams include Lookout Point (LOP), Detroit (DET), Green Peter (GRP), Hills Creek (HCR), Dexter (DEX), Cougar (CGR), Blue River (BLU), Foster (FOS), and Fall Creek (FCR). The results of the dams and reservoirs that were assessed for their VRI are briefly discussed in the sections below.

Table 3.22-1 shows the results of the Scenic Quality Inventory, where each dam received a Scenic Quality Rating based on the overall score from the key factors. All nine dams and reservoirs received a 'B' rating.

**Table 3.22-1. VRM Scenic Quality Inventory and Rating Chart for Select Dams and Reservoirs**

| Key Factors | Scores[1] by Dam/Reservoir | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **LOP** | **DET** | **GRP** | **HCR** | **DEX** | **CGR** | **BLU** | **FOS** | **FCR** |
| Landform | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Vegetation | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Water | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Color | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Influence of Adjacent Scenery | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Scarcity | 3 | 1 | 3 | 1 | 3 | 3 | 1 | 3 | 1 |
| Cultural Modifications | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Overall Score** | **18** | **13** | **15** | **13** | **15** | **15** | **13** | **15** | **13** |
| **Scenic Quality Rating[2]** | **B** | **B** | **B** | **B** | **B** | **B** | **B** | **B** | **B** |

[1] Numerical scores were adapted from BLM VRI Manual (BLM 1986b)

[2] A = 19 or more, B = 12-18, C = 11 or less.

Table 3.22-2 shows the Sensitivity Level Analysis Factors and Ratings, which includes indicators of public concern such as the amount of use and the public interest. Each dam's sensitivity level was rated in Table 3.22-3 based on the amount of use in visits per year and amount of visitor spending in dollars per year (USACE 2019h, USACE 2019j, USACE 2019k, USACE 2019l, USACE 2019n, USACE 2019p, USACE 2019q, USACE 2019r, USACE 2019s). The number of visits and visitor spending at each dam and reservoir is for Fiscal Year (FY) 2019. The metrics for low, moderate, and high for number of visits and visitor spending were adapted from the BLM VRI Manual (BLM 1986b) and established subjectively to best cover the data range. For example, the amount of visitors in FY 2019 among the dams ranged from tens of thousands to hundreds of thousands. Therefore, a metric was established to best capture what a low, moderate, and high value would be within that data range. Less than 50,000 visitors was given a 'Low' rating, between 50,000 and 75,000 visitors was given a 'Moderate' rating, and greater than 75,000 visitors was given a 'High' rating. This process was repeated for visitor spending; visitors spending in FY 2019 among the dams ranged from hundreds of thousands of dollars to over a million dollars. Therefore, a metric was established to best capture what a low, moderate, and high value would be within that data range. Less than $1,000,000 in visitor spending was given a "Low" rating, $1,000,000 to $5,000,000 in visitor spending was given a "Moderate" rating, and greater than $5,000,000 in visitor spending was given a "High" rating.

**Table 3.22-2. VRM Sensitivity Level Analysis Factors and Ratings**

| Factors of Public Concern | Rating[1] | | |
|---|---|---|---|
| | High | Moderate | Low |
| Amount of Use | Greater than 75,000 visits, FY 2019 | 50,000 – 75,00 visits, FY 2019 | Less than 50,000 visits, FY 2019 |
| Public Interest (Economic: Visitor Spending) | Greater than $5,000,000, FY 2019 | $1,000,000 - $5,000,000, FY 2019 | Less than $1,000,000, FY 2019 |

[1] Ratings were adapted from the BLM VRI Manual (BLM 1986b)

**Table 3.22-3. VRM Sensitivity Level Analysis for Select Dams and Reservoirs**

| Factors of Public Concern | Sensitivity Level Rating by Dam/Reservoir[1] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | LOP | DET | GRP | HCR | DEX | CGR | BLU | FOS | FCR |
| Amount of Use | Low | Moderate | High | Low | High | Low | Low | High | High |
| Public Interest | Moderate | Moderate | Moderate | Moderate | High | Low | Low | High | Moderate |
| **Overall Rating** | Low – Moderate | Moderate | High – Moderate | Low – Moderate | High | Low | Low | High | High – Moderate |

[1] USACE 2019h, USACE 2019j, USACE 2019k, USACE 2019l, USACE 2019n, USACE 2019p, USACE 2019q, USACE 2019r, USACE 2019s

Table 3.22-4 displays which distance zone each dam fell into based upon their visibility from travel routes or observation points. All nine dams fell in the foreground-middleground distance zones due to visibility from points of less than 3 to 5 miles away.

**Table 3.22-4. VRM Distance Zones for Select Dams and Reservoirs**

| Distance Zones | Dam/Reservoir | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | LOP | DET | GRP | HCR | DEX | CGR | BLU | FOS | FCR |
| Foreground-middleground | X | X | X | X | X | X | X | X | X |
| Background | | | | | | | | | |
| Seldom Seen | | | | | | | | | |

The scores from the Scenic Quality Inventory, Sensitivity Level Analysis, and distance zones were organized into a matrix included in Table 3.22-5. Based on their aggregate scores, each dam and reservoir was assigned a class which is displayed in Table 3.22-6.

**Table 3.22-5. Visual Resource Inventory Class Matrix[1] and Results**

| Visual Sensitivity Levels | | High | | Moderate | | Low |
|---|---|---|---|---|---|---|
| Special Areas | | I | | I | | I |
| Scenic Quality | A | II | | II | | II |
| | B | II | III* | III | IV* | IV |
| | C | III | IV* | IV | | IV |
| Distance Zones | | Foreground – middleground zone | | | | |

[1] VRI Class Matrix adapted from BLM VRI Manual (BLM 1986b)

* If a sensitivity level was rated between two levels, the lower-level Class was assigned.

**Table 3.22-6. Visual Resource Inventory Class Results by Dam**

| LOP | DET | GRP | HCR | DEX | CGR | BLU | FOS | FCR |
|---|---|---|---|---|---|---|---|---|
| IV | III | III | IV | II | IV | IV | II | III |

### *3.22.3.1 Detroit Dam and Reservoir*

The concrete Detroit Dam is a massive structure that is 463 feet (ft) high and 1,523 ft wide, and includes gated spillways and two hydropower generating units. Detroit Reservoir is 9 miles long and encompasses an area of 3,500 acres when the reservoir is full (USACE No Date-e). Detroit Dam is commonly used as a scenic viewpoint for the dam itself and is a designated stop along the Mt. Jefferson section of the Oregon Cascades Birding Trail. Viewers can also observe Big Cliff Reservoir below the dam and Detroit Reservoir above the dam. It has 30 miles of shoreline with campgrounds, marinas, Detroit Lake State Park, and other natural features (USACE No Date-e). Figure 3.22-2 shows the scenic view of Detroit Reservoir from the dam; and as shown in Figure 3.22-3, visitors can observe rockfaces and trees along North Santiam Highway (Google Earth No Date).

**Figure 3.22-2. View of Detroit Reservoir from the Dam (Google Earth No Date)**

**Figure 3.22-3. Heading East on North Santiam Highway, Detroit Reservoir (Google Earth No Date)**

A VRI was completed for Detroit Dam due to potential impacts from the Proposed Action and alternatives: Alternatives 1, 2A, 2B, and 4 propose the construction of a water temperature control tower and downstream passage structure; Alternative 3A proposes a deep fall reservoir drawdown and a deep spring reservoir drawdown; and Alternative 3B propose a deep fall reservoir drawdown. The Scenic Quality Evaluation resulted in an overall score of 13 and a 'B' Rating, as the presence of water increased the score. Sensitivity Level was moderate, and the dam was categorized within the foreground-middleground distance zone due to its visibility from highways and observation points of less than 3 to 5 miles away. Detroit Dam and Reservoir was rated as a Class III area, which is of moderate visual value.

### *3.22.3.2 Foster Dam and Reservoir*

Foster Dam is a rock-filled structure that includes a concrete gated spillway. The dam is 126 ft high and 4,565 ft wide and paved to enable drivers to cross over. Foster Reservoir is 3.5 miles long and encompasses an area of 1,220 acres when the reservoir is full (USACE No Date-j). As shown in Figure 3.22-4, visitors who cross the dam can view Foster's Reservoir above the dam. Visitors can also see the South Santiam River, marinas, parks, and the South Santiam Fish Hatchery below the dam (Google Earth No Date). It has parks, boat ramps, marinas, and observation points to allow scenic views of the water, trees, shrubs and rare wildlife such as the northern spotted owl, western pond turtle, and several amphibians (USACE No Date-j).

A VRI was completed for Foster Dam due to potential impacts from the Proposed Action and alternatives: Alternatives 1, 2A, 2B, and 4 propose the construction of a downstream passage structure. The Scenic Quality Evaluation resulted in an overall score of 15 and a 'B' Rating, as the presence of water and rare wildlife within this landscape increased the score. Sensitivity Level was high due to the high amount of use and public interest, and the dam was categorized within the foreground-middleground distance zone due to its visibility from highways and observation points of less than 3 to 5 miles away. Foster Dam and Reservoir was rated as a Class II area, which is of higher moderate visual value.


**Figure-3.22-4. Foster Dam Road and Foster Reservoir (Google Earth No Date)**

### *3.22.3.3 Green Peter Dam and Reservoir*

Green Peter Dam is located 11 miles northeast of Sweet Home, OR. The concrete dam is 327 ft high and 1,500 ft wide and includes a gated spillway and two hydropower generating units. Green Peter Reservoir is 10 miles long and encompasses an area of 3,720 acres when the reservoir is full (USACE No Date-k). North River Road is lined with trees on the dam side and rocky cliffs on the opposite side, obstructing motorists' view of the dam itself (Google Earth No Date). The overlook at the dam provides scenic views of the dam's structure, while other boat ramps and parks along the reservoir's 10-mile shoreline offer scenic views of water, vegetation, and rolling hills topped with various tree species. Osprey are also known to nest along the shorelines of the reservoir and may enhance aesthetic views of the area.

A VRI was completed for Green Peter Dam due to potential impacts from the Proposed Action and alternatives: Alternative 1 proposes the construction of a water temperature control tower, adult fish facility, and downstream passage structure; Alternative 2A and 2B proposes the construction of an adult fish facility and a deep fall reservoir drawdown; Alternative 3A proposes the construction of an adult fish facility, a deep fall reservoir drawdown, and a deep spring reservoir drawdown; and Alternative 3B proposes the construction of an adult fish facility, and a deep fall reservoir drawdown. The Scenic Quality Evaluation resulted in an overall score of 15 and a ‘B’ Rating, as the presence of water and the potential to see osprey nests along the shorelines increased the score. Sensitivity Level was high to moderate, and the dam was categorized within the foreground-middleground distance zone due to its visibility from highways and observation points of less than 3 to 5 miles away. The Green Peter Dam and Reservoir was rated as a Class III area, which is of moderate visual value.

#### *3.22.3.4 Cougar Dam and Reservoir*

Cougar Dam is located on the South Fork McKenzie River about 42 miles east of Eugene, Oregon. The rockfilled structure is 452 ft high and 1,600 ft wide and contains a gated concrete spillway, powerhouse, fish ladder, and temperature control tower that includes a portable floating fish collector. Cougar Reservoir is 6 miles long and encompasses an area of 1,280 acres when the reservoir is full. (USACE No Date-d). The Cougar Dam Overlook located on the northeast side of the dam allows viewers to look below the massive dam to the South Fork McKenzie River, and above the dam at Cougar Reservoir as seen in Figure 3.22-5, which is surrounded by forests and steep rocky cliffs (Google Earth No Date). The area contains many parks, campgrounds, and creeks; the reservoir itself is a designated stop along the Three Sisters section of the Oregon Cascades Birding Trail, where American peregrine falcons have been observed around the cliffs of the reservoir (USACE No Date-d).

**Figure 3.22-5. View of the Cougar Reservoir from the Cougar Dam Overlook (Google Earth No Date)**

A VRI was completed for Cougar Dam due to potential impacts from the Proposed Action and alternatives: Alternative 2A and 4 propose the construction of downstream passage structures; Alternative 2B and 3A propose a deep fall reservoir drawdown and a deep spring reservoir drawdown; and Alternative 3B proposes a deep fall reservoir drawdown. The Scenic Quality Evaluation resulted in an overall score of 15 and a 'B' Rating, as the presence of water and the Three Sisters section of the Oregon Cascades Birding Trail increased the score. Sensitivity Level was low, and the dam was categorized within the foreground-middleground distance zone due to its visibility from highways and observation points of less than 3 to 5 miles away. Cougar Dam and Reservoir was rated as a Class IV area, which is of least visual value.

#### *3.22.3.5 Blue River Dam and Reservoir*

Blue River Dam is located 38 miles east of Eugene, Oregon. The rockfilled structure is 270 ft high and 1,265 ft wide, and includes a gated concrete spillway. Blue River Reservoir is nearly 6 and a half miles long and encompasses an area of 1,009 acres when the reservoir is full (USACE No Date-b). A viewpoint located on the northeast end of the dam provides observers with a scenic view of the dam's massive structure, along with views of Blue River below the dam and the reservoir above the dam (Google Earth No Date) that includes western pond turtles and ospreys that have been known to roost (rest or sleep) in large trees and snags (USACE No Date-b). Forest and steep, rocky cliffs encompass most of the reservoir, while boat ramps and campgrounds provide access to the scenic views of the reservoir and surrounding forests (USACE No Date-b).

A VRI was completed for Blue River Dam due to potential impacts from the Proposed Action and alternatives: Alternative 3A and Alternative 3B propose the construction of an adult fish facility and a deep fall reservoir drawdown. The Scenic Quality Evaluation resulted in an overall score of 13 and a ‘B’ Rating, as the presence of water increased the score. Sensitivity Level was low, and the dam was categorized within the foreground-middleground distance zone due to its visibility from highways and observation points of less than 3 to 5 miles away. Blue River Dam and Reservoir was rated as a Class IV area, which is of least visual value.

#### *3.22.3.6 Lookout Point (Meridian) Dam and Reservoir*

Lookout Point Dam is located on the Middle Fork Willamette River about 22 miles southeast of Eugene, OR. It is an earth and gravel-filled dam that is 276 ft high and 3,381 ft wide with a concrete gated spillway, powerhouse, and the Dexter Service Building, a USACE Office. Lookout Point Reservoir is over 14 miles long and encompasses an area of 4,360 acres when the reservoir is full (USACE No Date-m). As shown below in Figure 3.22-6, visitors to the dam can stop at Meridian Park and observe the expansive reservoir surrounded by rocky cliffs and rolling hills topped with various tree species. The area surrounding the reservoir includes several parks, boat ramps, and creeks that provide scenic views of the water, vegetation, and rolling forested hills. The reservoir and rolling hills to the northeast are visible from Willamette Highway through breaks in the treeline (Google Earth No Date). Visitors may also spot rare species, including the northern spotted owl and western pond turtles. Bald eagles are known to winter and regularly nest at Lookout Point (USACE No Date-m). Lowell Covered Bridge is located west of the dam and provides views of the dam, surrounding water bodies, forests, and rolling hills (Google Earth No Date).

**Figure 3.22-6. View of Lookout Point Reservoir from Dam (Google Earth No Date)**

A VRI was completed for Lookout Point Dam due to potential impacts from the Proposed Action and alternatives: Alternative 1 and Alternative 4 propose the construction of a water temperature control tower and a downstream passage structure; Alternative 2A and 2B propose the construction of a downstream passage structure; Alternative 3A propose a deep fall reservoir drawdown and a deep spring reservoir drawdown; and Alternative 3B propose a deep fall reservoir drawdown. The Scenic Quality Evaluation resulted in an overall score of 18 and a ‘B’ Rating, as the presence of water, the rare wildlife, and views of the dam from Lowell Covered Bridge increased the score. Sensitivity Level was low to moderate, and the dam was categorized within the foreground-middleground distance zone due to its visibility from highways and observation points of less than 3 to 5 miles away. Lookout Point Dam and Reservoir was rated as a Class IV area, which is of least visual value.

#### *3.22.3.7 Hills Creek Dam and Reservoir*

Hill Creek Dam is located 4 miles southwest of Oakridge, Oregon. It is an earthfilled dam that rises 304 ft high and 2,235 ft wide and includes a gated concrete spillway, two hydropower generating units, a powerhouse, an outlet to regulate reservoir levels, and a hatchery and ranger station located west of the dam. Hills Creek Reservoir is nearly 8 miles long and encompasses an area of 2,735 acres when the reservoir is full. The area around the reservoir contains picnic areas, campgrounds, creeks, and multiple viewpoints of the dam itself. From scenic viewpoints in this area, visitors can observe the massive earthen structure, the reservoir, forested hills, and wildlife such as birds that stop along the Three Sisters section of the Oregon Cascades Birding Trail (USACE No Date-l).

A VRI was completed for Hills Creek Dam due to potential impacts from the Proposed Action and alternatives: Alternative 3A proposes the construction of an adult fish facility and a deep fall reservoir drawdown; Alterative 3B proposes the construction of an adult fish facility, a deep fall reservoir drawdown, and a deep spring reservoir drawdown; and Alternative 4 proposes the construction of a water temperature control tower, an adult fish facility, and a downstream passage structure. The Scenic Quality Evaluation resulted in an overall score of 13 and a 'B' Rating; the presence of water increased the score. Sensitivity Level was low to moderate, and the dam was categorized within the foreground-middleground distance zone due to its visibility from highways and observation points of less than 3 to 5 miles away. Hills Creek Dam and Reservoir was rated as a Class IV area, which is of least visual value.

#### *3.22.3.8 Dexter Dam and Reservoir*

Dexter Dam is located about 22 miles southeast of Eugene, Oregon. It is an earth and gravel-filled embankment dam that is 93 ft high and 2,739 ft wide with concrete gated spillways, a powerhouse, and a fish facility. Dexter Reservoir is almost 3 miles long and encompasses an area of 1,024 acres when the reservoir is full (USACE No Date-f). Willamette Highway runs along the southern edge of Dexter Reservoir and provides scenic views of the water, trees, and hills, while Shore Line Drive runs northeast of the dam into the City of Lowell, where it crosses the reservoir as Lowell Covered Bridge (Google Earth No Date). Figure 3.22-7 below shows where Shore Line Drive crosses Dexter Reservoir at Lowell Covered Bridge. This mixture of natural landscape along with urban structures such as the dam, bridge, and the City of Lowell on the northern embankment provide a diverse assortment of landscape features for visitors to observe.

**Figure 3.22-7. Lowell Covered Bridge, Dexter Reservoir (Google Earth No Date)**

A VRI was completed for Dexter Dam due to potential impacts from the Proposed Action and alternatives: Alternative 1 and Alternative 4 propose the construction of an adult fish facility. The Scenic Quality Evaluation resulted in an overall score of 15 and a 'B' Rating, as the presence of water and views of Lowell Covered Bridge, the City of Lowell, and other urbanized features that mix with the natural landscape increased the score. Sensitivity Level was moderate, and the dam was categorized within the foreground-middleground distance zone due to its visibility from highways and observation points of less than 3 to 5 miles away. Deter Dam and Reservoir was rated as a Class II area, which is of higher moderate visual value.

#### *3.22.3.9 Fall Creek Dam and Reservoir*

Fall Creek Dam is located on Fall Creek, a major tributary to the Middle Fork Willamette River, one mile upstream of Unity, Oregon and 25 miles upstream of Eugene and Springfield, Oregon. It is a rock filled, earth dam that is 205 ft high and 5,050 ft wide with a concrete spillway, two spillway gates, and a regulating outlet (USACE No Date-h). North Shore Park and Winberry State Recreation Site are located on the north and south sides of the dam, respectively. Big Fall Creek Road stretches along the north side of the reservoir while Peninsula Road traverses the southern shore. These roads provide scenic views of the forested landscape, with breaks in the tree line opening up to views of the reservoir. Moving away from the dam to the northeast corner of the reservoir lies Fall Creek State Recreation Area and Cascara Campground which provides a dense and rustic forested space along the narrowing stretches of Fall Creek reservoir.

A VRI was completed for Fall Creek Dam due to potential impacts from No Action alternative: ongoing reservoir drawdown annually during late fall to its lowest outlet. The Scenic Quality Evaluation resulted in an overall score of 13 and a ‘B’ Rating, as the presence of water increased the score. Sensitivity Level was high – moderate, and the dam was categorized within the foreground-middleground distance zone due to its visibility from highways and observation points of less than 3 to 5 miles away. Fall Creek Dam and Reservoir was rated as a Class III area, which is of moderate visual value.

### 3.22.4 Environmental Effects

This section discusses the potential effects of the Proposed Action and alternatives on visual resources. The discussion includes the methodology, the measures within the action alternatives that were analyzed, a summary of the effects, and a detailed analysis for each alternative.

#### *3.22.4.1 Methodology*

This analysis uses a three-step process to determine potential visual effects at each dam, which are discussed in detail in 3.22.4.1.1 (Visual Resource Contrast Rating), 3.22.4.1.2 (Evaluation Criteria), and 3.22.4.1.3 (VRM Class Management Objectives).

1. Visual Resource Contrast Rating – The visual resource contrast rating of each dam is determined by comparing the proposed project measures with the major features in the existing landscape using the basic design elements of form, line, color, and texture.
2. Evaluation Criteria – For purposes of this NEPA analysis, the visual resources contrast ratings correspond with the magnitude (how much or severity) of potential effects. The evaluation criteria (shown in Table 3.22-7 below) also include duration (how long) and extent (how far or sphere of influence).
3. VRM Class Management Objectives – The visual contrast rating is compared to the VRM Class management objectives for each dam (as established in the Affected Environment) to ensure that level of change is allowed at each dam. If a dam’s level of change is not within its Class management objectives, design adjustments or mitigations could be required. This is a subjective process due to the varying degrees of change allowed per Class rating.

##### *3.22.4.1.1 Visual Resource Contrast Rating*

The first part of the BLM Visual Resource Management (VRM) process, the BLM Visual Resource Inventory (VRI), is described for select dams in the Affected Environment (Section 3.22.3). A more detailed description of how each dam and reservoir was rated in the Scenic Quality Inventory, Sensitivity Level Analysis, and Distance Zones is included in Appendix T. The second part in the BLM VRM process is the visual resources analysis, or the visual resource contrast rating. The contrast rating determines the degree of contrast that an effect would have on the landscape, and can range from “none” or no visible contrast, to “strong” or a contrast that dominates the landscape.

Basic design elements, such as form, line, color, and texture, are used to make this comparison and to describe the visual contrast created by the measures. Form is defined by the changes in the shape or mass of landforms or structures; the degree of change depends on how dissimilar the introduced forms are to those continuing to exist in the landscape. Line is defined by the changes in edge types and interruption or introduction of edges, bands, and silhouette lines; new lines may differ in their sub elements (boldness, complexity, and orientation) from existing lines. Color is defined by the changes in value and hue that create the greatest contrast; other factors such as chroma, reflectivity, and color temperature may also increase the contrast. Texture is defined by the changes in grain, density, and internal contrast; other factors such as irregularity and directional patterns of texture may affect the rating (BLM 1986a).

Therefore, potential alterations to the form, line, color, and texture of the landscape from proposed measures are evaluated to determine the contrast rating (i.e., none, weak, moderate, and strong). For example, the contrast rating would be "none" if the alteration would not visible and would not attract attention, or more specifically, if the proposed measure would not:

1. Alter the shape and mass of the landscape (form);
2. Alter edge types, bands, and silhouette lines of the landscape (line);
3. Alter the hue and coloration of the landscape (color); and
4. Alter the grain, density, and internal contrast of the landscape (texture).

The degree of the rating increases based on the level of contrast determined for each basic design element. These basic design elements are subjective to the analyst, and therefore the interpretation of the effect can vary.

#### *3.22.4.1.2 Evaluation Criteria*

For purposes of this analysis, the VRM's contrast rating system has been adapted into the evaluation or significance criteria. Contrast ratings (i.e., none, weak, moderate, and strong) correspond to the magnitude of effects (i.e., negligible, minor, moderate, and major or significant) on visual resources. Effects range from negligible (a contrast that is not visible and does not attract attention) to major (a contrast that demands attention, cannot be overlooked, and dominates the landscape). In the event that no modification or contrast change would occur, the magnitude of effects would be none and are not analyzed further.

Table 3.22-7 describes the evaluation criteria for magnitude, duration, and extent, and provides a definition for the scale of each effect factor. Extent was derived from the amount of use recorded at each location, as this metric was used for the Sensitivity Level Analysis for the VRI in the Affected Environment. Note that the definitions for short term, medium term, and long term are the same for all resources.

**All comparisons of effects for each action alternative are in comparison to the NAA unless stated otherwise.**

**Table 3.22-7. Evaluation Criteria for Potential Effects to Visual Resources**

| Term | Definition |
|---|---|
| **Magnitude** | |
| Negligible | A modification cannot be seen and does not attract attention. |
| Minor | A modification can be seen, but does not attract attention. |
| Moderate | A modification begins to attract attention and begins to dominate the characteristic landscape. |
| Major | A modification demands attention, cannot be overlooked, and dominates in the landscape. |
| **Duration** | |
| Short term | Alteration lasts for the duration of small construction project, and is continuous for less than 2 years. |
| Medium term | Alteration is limited to the duration of large construction projects, and is continuous for a period of 2-5 years. |
| Long term | Alteration is permanent or lasts continuously beyond operation changes or the completion of all construction projects; the alteration recurs at regular intervals (i.e., deep drawdowns that occur for a 3-week period in the fall and/or spring); or the alteration occurs intermittently. |
| **Extent** | |
| Small | Visual quality is altered for less than 50,000 visitors. |
| Medium | Visual quality is altered for 50,000 to 75,000 visitors. |
| Large | Visual quality is altered for more than 75,000 visitors. |

Source: BLM 1986a

#### *3.22.4.1.3 VRM Class Management Objectives*

Table 3.22-8 provides the VRM Management Objectives based on Class. Higher Classes (I and II) are most valued and management activities aim to preserve the existing character of the landscape. Lower Classes (III and IV) represent lower value landscapes and may provide more allowance for management activities to alter its appearance. Class ratings (i.e., I, II, III, IV) roughly correspond with the degrees of contrast or change (i.e., none, weak, moderate, and strong), although these can vary based on the nature of the management activity or measure. A measure that results in a high level of change in a higher Class may be subject to mitigation measures.

**Table 3.22-8. VRM Class Management Objectives**

| Class | Management Objective | Degree of Contrast | Dam/ Reservoir |
|---|---|---|---|
| Class I | The objective of this Class is to preserve the existing character of the landscape. It provides for natural ecological changes, and does not preclude very limited management activity. Any change to the landscape must not attract attention. | None (or Negligible) | N/A |
| Class II | The objective of this Class is to retain the existing character of the landscape. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape. | Weak (or Minor) | Dexter (DEX), Foster (FOS) |
| Class III | The objective of this Class is to partially retain the existing character of the landscape. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape. | Moderate | Detroit (DET), Green Peter (GRP), Fall Creek (FCR) |
| Class IV | The objective of this Class is to provide for management activities which require major modification of the existing character of the landscape. Management activities may dominate the view and be the major focus of viewer attention. However, every attempt should be made to minimize the effect of these activities through careful location, minimal disturbance, and repeating the basic elements. | Strong (or Major) | Lookout Point (LOP), Hills Creek (HCR), Cougar (CGR), Blue River (BLU) |

Source: BLM 1986a

As described above, VRM Class Management Objectives are compared to the level of change or contrast rating the proposed project measure would create to determine if the effect would be within each dam's management objective. If a dam's level of change is not within its Class management objectives, design adjustments or mitigations could be required.

### *3.22.4.2 Measures Analyzed for Visual Resources*

Measures under the action alternatives that could have an effect on visual resources include construction of water temperature control (WTC) towers (#105), construction of adult fish facilities (AFF) (#722), construction of structural downstream fish passage (#392), deeper fall reservoir drawdowns for fish passage (#40), and spring reservoir drawdowns for downstream fish passage (#720).

The following measures would have no effect on visual resources, and are therefore not discussed further.

- Gravel augmentation below dams (#384);
- Adapt hatchery program (#719);
- Maintenance of existing and new fish release sites above dams (#9);
- Continued operation of existing adult fish facilities;
- Operation, maintenance, repair, replacement, and rehabilitation;
- Foster fish ladder temperature improvement (#479);
- Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166);
- Use spillway for surface spill in summer (#721);
- Structural improvements to reduce total dissolved gas (#174);
- Augment instream flows by using the inactive pool (#718);
- Augment instream flows by using the power pool (#304);
- Reduce minimum flows to Congressionally authorized minimum flow requirements (#723);
- Integrated temperature and habitat flow regime (#30a);
- Refined integrated temperature and habitat flow regime (#30b);
- Restore upstream and downstream passage at drop structures (#639);
- Provide Pacific lamprey passage and infrastructure (#52); and
- Pass water over spillway in spring for fish passage (#714).

A summary of the effects to visual resources discussed in the following sections is provided in Table 3.22-9. Note that where a range of potential effects would occur, the most severe magnitude of adverse effects and the least magnitude of beneficial effects for each alternative is listed to present the most conservative range of potential effects. Also, the extent of effects includes all reservoirs where potential effects would occur, even if the most severe adverse effect or the least beneficial effect does not occur at that reservoir. Discussion of all adverse and beneficial effects is presented below.

**Table 3.22-9. Summary of Effects to Visual Resources Under Each Alternative***

| Effect Factor | Alternative | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **NAA** | **1** | **2A** | **2B** | **3A** | **3B** | **4** | **5** |
| | **Short-Term** | | | | | | | |
| Magnitude | Moderate adverse | Moderate adverse | Moderate adverse | Moderate adverse | Moderate adverse | Moderate adverse | Moderate adverse | Moderate adverse |
| Extent | Large (FCR) | Large (FOS, FCR) | Large (FOS, GRP, FCR) | Small (CGR)<br>Large (FOS, GRP, FCR) | Small (LOP, HCR, CGR, BLU)<br>Medium (DET)<br>Large (GRP, FCR) | Small (LOP, HCR, CGR, BLU)<br>Medium (DET)<br>Large (GRP, FCR) | Large (FOS, FCR) | Small (CGR)<br>Large (FOS, FCR) |
| | **Medium-Term** | | | | | | | |
| Magnitude | None | Minor adverse | Minor adverse | Minor adverse | Minor adverse | Minor adverse | Minor adverse | Minor adverse |
| Extent | None | Small (LOP)<br>Medium (DET)<br>Large (GRP, DEX) | Small (LOP, CGR)<br>Medium (DET)<br>Large (GRP) | Small (LOP)<br>Medium (DET)<br>Large (GRP) | Small (BLU, HCR)<br>Large (GRP) | Small (BLU, HCR)<br>Large (GRP) | Small (HCR, LOP, CGR)<br>Medium (DET)<br>Large (DEX) | Small (LOP)<br>Medium (DET)<br>Large (GRP) |
| | **Long-Term (Permanent, Intermittent, and/or Recurring)** | | | | | | | |
| Magnitude | Major adverse | Major adverse; minor beneficial | Major adverse; minor beneficial | Major adverse; minor beneficial | Major adverse; minor beneficial | Major adverse; minor beneficial | Major adverse; minor beneficial | Major adverse; minor beneficial |
| Extent | Large (FCR) | Small (LOP)<br>Medium (DET)<br>Large (FOS, GRP, DEX, FCR) | Small (LOP, CGR)<br>Medium (DET)<br>Large (FOS, GRP, FCR) | Small (LOP, CGR)<br>Medium (DET)<br>Large (FOS, GRP, FCR) | Small (LOP, HCR, CGR, BLU)<br>Medium (DET)<br>Large (GRP, FCR) | Small (LOP, HCR, CGR, BLU)<br>Medium (DET)<br>Large (GRP, FCR) | Small (LOP, HCR, CGR)<br>Medium (DET)<br>Large (FOS, DEX, FCR) | Small (LOP, CGR)<br>Medium (DET)<br>Large (FOS, FCR) |

| Effect Factor | Alternative | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **NAA** | **1** | **2A** | **2B** | **3A** | **3B** | **4** | **5** |
| Duration Type | Recurring | Permanent and/or Recurring | Permanent and/or Recurring | Permanent and/or Recurring | Permanent and/or Recurring | Permanent and/or Recurring | Permanent and/or Recurring | Permanent and/or Recurring |

*This summary table does not include the effects from near-term operations due to the uncertainty of the implementation and duration of these operations.

In the following subsections, the effects are discussed for the measures analyzed in the alternatives, for the No Action Alternative, and for each of the action alternatives.

### *3.22.4.3 Discussion of Effects by Measure*

This section applies the methodology described above for each measure analyzed for visual resources to determine the potential effect. Where possible, the discussion of the magnitude and duration of effects is grouped by measures that would have similar effects, such as the construction of WTC towers and structural downstream fish passages. These effects by measure will then be referenced in the action alternatives analysis that follows. Potential effects that occur at one or many dam(s) are grouped by VRM class as appropriate, and this discussion is included under the appropriate alternative. The extent of effects is discussed by dam/reservoir under the appropriate alternative.

This Draft PEIS discusses general, qualitative effects from construction at the programmatic level. Site-specific project details for each construction measure will be determined during the implementation phase. Structural measures with a construction phase that will affect visual resources include construction of WTC towers, AFFs, and structural downstream fish passage, and deeper fall and spring reservoir drawdowns. Subsequent tiered NEPA documents would discuss detailed site-specific effects of construction.

#### *3.22.4.3.1 Construct water temperature control (WTC) towers (#105), Construct structural downstream fish passages (#392), and Construct adult fish facilities (AFFs) (#722)*

The contrast rating or the magnitude of effects from the construction of WTC towers (#105), structural downstream fish passages (#392), and/or AFFs (#722) would be minor in the short, medium, and long term at all of the dams. These potential effects are determined below and referred to in the action alternative analysis.

In general, the WTC towers, structural downstream fish passages, and AFFs would be located next to the dam. Construction activities and equipment associated with these measures, including work vehicles, machinery, and building materials, would likely be visible during the duration of the construction phase. Construction activities would blend into the already existing landscape of the dams by generally matching in color, texture, line, and form. Construction vehicles and equipment would generally match the coloration of the dams, contain a similar rectangular form that is comparable to the dams, have straight lines comparable to the dams, and have similar grain, density, and overall textured contrast similar to the dams. Because these vehicles and equipment would not drastically alter any of the basic design elements in the landscapes, the contrast rating and magnitude of adverse effects would be minor, as the vehicles and equipment would be seen but would not attract attention and would not dominate the landscapes. There would be a short-term effect to the landscape at Foster because the modification to the existing spill (fish) weir would take less than a year to be completed. There would be a medium-term effect to the landscape from the WTC towers, structural downstream fish passages, and AFFs because the construction activities from these measures would take between two and five years to be completed.

Once construction is complete, the WTC towers, structural downstream fish passages, and AFFs would blend into the already existing landscape of the dams by generally matching in color, texture, line, and form. These structures would likely use similar building materials to the dams, match the gray coloration of the dams, contain a similar rectangular form that is comparable to the dams, have straight lines comparable to the dams, and have similar grain, density, and overall textured contrast similar to the dams. It would also likely add to the visual interest that the dams already provide, which could be viewed as a beneficial effect based on the perspective of the observer. Because these structures would not drastically alter any of the basic design elements in the landscapes, the contrast rating and magnitude of adverse and beneficial effects would be minor, as these structures would be seen but do not attract attention and do not dominate the landscapes. There would be a long-term effect to the landscapes because these structures would be permanent.

Therefore, potential adverse effects from the construction of the WTC towers, structural downstream fish passages, and AFFs would be minor in magnitude, and short and medium term in duration. In the long term, potential adverse and beneficial effects from these structures would also be minor in magnitude.

###### *3.22.4.3.2 Fall Creek drawdown, Deeper fall reservoir drawdowns for fish passage (#40), and Spring reservoir drawdowns for downstream fish passage (#720)*

The contrast rating or the magnitude of effects from the Fall Creek Drawdown, deeper fall reservoir drawdowns (#40), and spring reservoir drawdowns (#720) would be moderate in the short term and major in the long term at all the reservoirs, regardless of the exact drawdown level. These potential effects are determined below and referred back to under all alternatives.

Shoreline erosion is not expected to occur, given that the drawdowns would only last for three weeks. However, suspended solids would mobilize as the deep drawdowns occur. This would lead to sediments, organic materials, and other debris being washed downstream and affecting water color and clarity (USACE No Date-p). This would also have a noticeable effect on the basic design elements of color, texture, and form. Color would change slightly to a darker color with the introduction of darker clays, silts, and sediments; texture would change slightly with the introduction of grainy sediment particles and other larger suspended particulate materials; and form would change slightly with the introduction of a variety of irregular shapes, sizes, and masses from the suspended solids. Because sediment transport would noticeably alter the basic design elements in the landscapes, the contrast rating and magnitude of adverse effects at all the dams and reservoirs would be moderate, as sediment transport downstream would begin to attract attention and begin to dominate the landscapes. There would be a short-term effect to the landscapes for the 3-week drawdown period; water clarity and coloration would return to baseline conditions in the days to weeks that follow.

Reservoir drawdowns could reveal mudflats, substrate, tree stumps, and other submerged littoral zone attributes (submerged vegetation, roots, sediments, rocks, snails, shells, etc.), and would have an effect on the basic design elements of color, texture, line, and form. Color would change substantially with the loss of surface water and the exposure of previously submerged littoral zone attributes containing darker colors; texture would change substantially from the water's smooth surface to rough, more grainy surfaces with the exposure of mudflats or other submerged substrate; line would change substantially from the solid, smooth, and curved lines of the water's surface and edge to jagged, irregularly shaped lines with the introduction of submerged littoral zone attributes; and form would change substantially from the uniform and ubiquitous shape and mass of the reservoirs to a variety of irregular shapes, sizes, and masses with the exposure of submerged littoral zone attributes. An example of this difference can be seen in Section 3.22.4.4. It should be noted that the typical vegetation cover around the reservoir is unlikely to change, meaning trees, grasses, and other plants are not expected to expand into the reservoirs. Because the drawdowns would substantially alter the basic design elements in the landscapes, the contrast rating and magnitude of adverse effects at all the dams and reservoirs would be major, as the reservoir drawdowns would demand attention, cannot be overlooked, and dominate the landscapes. There would be a long-term, recurring effect to the landscapes because while this elevation would only be held for three weeks, it would occur annually. Mitigation measures may be recommended for some project locations where reservoir drawdowns would not be consistent with their Class Management Objectives. Mitigation measures could include limiting drawdowns elevations, monitoring turbidity downstream, or installing temporary signage to inform visitors of the dates and times of reservoir drawdowns so that these viewsheds can be avoided.

##### *3.22.4.3.3 Near-Term Operations*

The contrast rating or the magnitude of effects from near-term operations would be major in the short term or medium term at all the dams. These potential effects are determined below and referred back to under Alternatives 2A, 2B, 3A, 3B, 4, and 5.

Near-term operations that would potentially affect visual resources include:

- Deep drawdown and RO prioritization for improved downstream fish passage at Green Peter, Cougar, and Lookout Point dams;
- Delayed reservoir refill and RO prioritization for improved downstream fish passage at Cougar and Fall Creek dams;
- Extended deep drawdown and RO prioritization for improved downstream fish passage at Fall Creek; and
- Delay reservoir refill and utilize spillway in the spring for improved downstream fish passage at Foster dam.

As discussed above in Section 3.22.4.3.2 (Reservoir Drawdowns), potential adverse effects from revealed mudflats, substrate, tree stumps, and other submerged littoral zone attributes would be major in magnitude. It should be noted that the duration and recurrence of near-term operations ultimately would depend on when other operations or structures proposed at a location in the action alternatives can be implemented; therefore, duration of effects would be short term and/or medium term depending on the implementation process of measures in the action alternatives. Effects would be large in extent at Green Peter, Foster, and Fall Creek Dams and Reservoirs because these dams recorded greater than 75,000 visitors in FY 2019; and small at Lookout Point and Cougar because these dams recorded less than 50,000 visits in FY 2019. These measures would generally be consistent with the Class IV management activities for Cougar and Lookout Point. However, long-term effects from reservoir drawdowns and delayed refills would not be consistent with Class II or III management activities at Foster, and Green Peter and Fall Creek Dams and Reservoirs, respectively. Mitigation measures would be recommended to reduce the effect these measures would have to visual resources.

#### *3.22.4.4 No Action Alternative*

Under the NAA, revetments would be maintained using nature-based engineering or altered for aquatic ecosystem restoration (#9). Revetments are located along the Willamette River and its tributaries and not along reservoir shorelines. As such, they were not considered key elements to visual resources as they do not occur at the 13 USACE dams and reservoirs and the locations of revetments cannot be seen from project locations. Since revetments were not subjected to the VRM process, maintaining or altering revetments would have no effect on visual resources.

Under the NAA, Fall Creek reservoir would continue to be drawn down annually to its lowest outlet for a few weeks in November, potentially lasting into December. As discussed in Section 3.22.4.3.2, the drawdowns would substantially alter the basic design elements in the landscape. An example of these drawdowns can be seen below. Figure 3.22-8 shows Fall Creek Dam and Reservoir at full capacity, and Figure 3.22-9 shows the reservoir at a drawdown elevation of 10 feet above the ROs and near the historical streambed.

As discussed above in Section 3.22.4.3.2, potential adverse short-term effects from sediment transport during drawdowns would be moderate in magnitude. Potential adverse long-term, recurring effects would be major in magnitude. Effects would be large in extent because Fall Creek recorded greater than 75,000 visitors in FY 2019. Fall Creek is listed as a Class III area, meaning its objectives are to partially retain the existing character of the landscape. Short-term potential adverse effects from sediment transport during drawdowns would be consistent with the Class III Management Objectives. However, long-term effects from reservoir drawdowns would not be consistent with Class III management activities.

**Figure 3.22-8. View of Fall Creek Dam and Reservoir at full capacity (USACE No Date-h)**

**Figure 3.22-9. View of Fall Creek Dam and Reservoir during a deep reservoir drawdown to 10 ft above the ROs (USACE No Date-o)**

### *3.22.4.4.1 Climate Change*

Climate change would adversely affect visual resources within the WVS. Ambient air temperature changes, low summer flows, and reservoir evaporation could potentially affect visual resources at project locations by lowering the reservoir level and altering basic design elements from surface water landscapes to terrestrial landscapes. Long-lasting droughts and warm spells could compromise earth dams as a result of soil cracking due to drying, and would potentially erode or alter landscape characteristics (See Appendix F1); this could be of particular concern at earth and gravel-filled dams such as Lookout Point and Dexter Dams, and earth-filled dams such as Hills Creek Dam. Warmer temperatures from climate change could also provide favorable conditions for the propagation of harmful algal blooms (HABs), which can discolor, cloud, or cover the water's surface and affect visual resources. Wildfire intensity and frequency associated with climate change would drastically alter the basic design elements of a forested, natural landscape by substantially changing the color, form, and texture due to the burnt, darkened, and decimated landscapes that follow wildfires. Wildfire ash can also land in reservoirs, streams, and rivers, increasing turbidity and affecting the visual resources of those water bodies.

Effects from the Fall Creek Drawdown would be moderate in the short term and major in the long term. Climate change could exacerbate short-term effects from sediment transport during drawdowns, as increased wildfire ash, HABs, and erosion would further increase turbidity and noticeably alter the basic design elements in the landscapes. As such, the effects of climate change and the Fall Creek Drawdown would be moderate to major in the short term.

Climate change could also exacerbate long-term, recurring effects from drawdowns and further change the basic design elements of color, texture, and form. If reservoir levels are already lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity, affecting water color and clarity. This would have a noticeable effect on the basic design elements of color, texture, and form. Color would change slightly to a darker color with the introduction of darker clays, silts, and sediments; texture would change slightly with the introduction of grainy sediment particles and other larger suspended particulate materials; and form would change slightly with the introduction of a variety of irregular shapes, sizes, and masses from the suspended solids. As such, climate change and the drawdowns would further exacerbate the already major and long-term, recurring effects. All above-mentioned effects would be large in extent.

#### *3.22.4.5 Alternative 1. Improve Fish Passage Through Storage-Focused Measures*

Under Alternative 1, adverse effects from the construction of the WTC towers, structural downstream fish passages, and AFFs would be minor in magnitude in the medium and long term. The extent of effects would be large at Green Peter; medium at Detroit; and small at Lookout Point. Potential beneficial effects from the construction of WTC towers, structural downstream fish passages, and AFFs would be minor in the long term. The extent of effects would be large at Foster in the short term and long term due to the construction of a structural downstream fish passage in the form of a modification to the existing spill (fish) weir. The measures under this alternative would be consistent with the Class II, III, and IV management activities for Foster, Detroit and Green Peter, and Lookout Point, respectively.

Furthermore, as discussed in Section 3.22.4.3.2 (Fall Creek Drawdown, Deeper Fall Reservoir Drawdowns for Fish Passage, and Spring Reservoir Drawdowns for Downstream Fish Passage) and in Section 3.22.4.4 (NAA), reservoir drawdowns at Fall Creek would continue to have moderate short-term effects and major long-term, recurring effects. Short-term effects would be consistent with Class III management objectives, but long-term effects would not, and mitigation measures would be recommended to reduce the effect these measures would have to visual resources.

In general, all of the major effects to visual resources would occur because of the drawdown(s). One drawdown – the Fall Creek drawdown – would occur under the NAA, Alternative 1, and Alternative 4; and the magnitude of effects would be major under these alternatives. Under Alternatives 3A and 3B, the alternatives with the most drawdowns, 10 drawdowns would occur across seven reservoirs (including the drawdown at Fall Creek). While the severity of effects would still be major, effects under Alternatives 3A and 3B would be more severe or more adverse than under Alternative 1 (and the NAA and Alternative 4). As such, Alternative 1 would have the same effect as Alternative 4, and would be less severe compared to Alternative 2A, 2B, 3A, 3B, and 5.

#### *3.22.4.5.1 Construction of WTC Towers, Structural Downstream Fish Passages, and AFFs*

Under Alternative 1, the construction of large concrete WTC towers and of structural downstream fish passages in the forms of Floating Screen Structures (FSSs) consisting of large screen barges that float up or down with reservoir stage would occur at Detroit Dam, Green Peter Dam, and Lookout Point Dam. The construction of a structural downstream fish passage in the form of a modification to the existing spill (fish) weir would occur at Foster Dam. The construction of an AFF would occur at Green Peter Dam.

**Foster Dam and Reservoir (Class II)**

At Foster, the structural downstream fish passage would be a modification to the existing spill (fish) weir, located on the dam. As discussed above in Section 3.22.4.3.1 (Construction of WTC Towers, Structural Downstream Fish Passages, and AFFs), potential adverse short- and long-term permanent effects from the structural downstream fish passages would be minor in magnitude. Effects would be large in extent because Foster recorded greater than 75,000 visits in FY 2019. Foster is listed as a Class II area, meaning its objective is to retain the existing character of the landscape. Construction of the structural downstream fish passage would be consistent with Class II management activities.

**Detroit and Green Peter Dams and Reservoirs (Class III)**

At Detroit and Green Peter, the WTC towers, structural downstream fish passages, and AFF would be located next to the existing dams. As discussed above in Section 3.22.4.3.1 (Construction of WTC Towers, Structural Downstream Fish Passages, and AFFs), potential adverse medium- and long-term permanent effects from the construction of WTC towers, structural downstream fish passages, and AFFs would be minor in magnitude. Effects would be medium in extent because Detroit recorded between 50,000 and 75,000 visits in FY 2019; and large in extent because Green Peter recorded more than 75,000 visits in FY 2019. Detroit and Green Peter are both Class III areas, meaning its objective is to partially retain the existing character of the landscape. The construction of WTC towers, structural downstream fish passages, and AFFs would be consistent with Class III management activities.

**Lookout Point Dam and Reservoir (Class IV)**

At Lookout Point, the WTC tower and structural downstream fish passage would be located next to the existing dam. As discussed above in Section 3.22.4.3.1 (Construction of WTC Towers, Structural Downstream Fish Passages, and AFFs), potential adverse medium- and long-term permanent effects from the construction of WTC tower and structural downstream fish passage would be minor in magnitude. Effects to the landscape would be small in extent because Lookout Point recorded less than 50,000 visits in FY 2019.

Lookout Point is a Class IV area, meaning its objective is to allow major modification of the existing character of the landscape. Construction of the WTC tower and the structural downstream fish passage would be consistent with Class IV management activities.

*3.22.4.5.2 Climate Change*

As discussed in Section 3.22.4.4.1, climate change would adversely affect visual resources within the WVS, including more intense wildfires, low summer flows, long-lasting droughts, earthen dams cracking and drying, and HABs which would alter the basic design elements of the characteristic landscape.

Under Alternative 1, alterations to the visual landscape from the construction of WTC towers, structural downstream fish passage structures, and AFFs would have minor effects in the medium and long term. Climate change would not exacerbate medium-term visual effects from the presence of construction vehicles or the long-term permanent effects from the erection of these structures. The effects of climate change and the construction measures under Alternative 1 would still be minor in the medium and long term.

Effects from the Fall Creek Drawdown would be moderate in the short term and major in the long term. As described under the NAA, climate change could exacerbate short-term effects from sediment transport during drawdowns; the effects of climate change and the drawdowns would be moderate to major in the short term. Climate change could also exacerbate long-term, recurring effects from drawdowns and further change the basic design elements of color, texture, and form. If reservoir levels are already lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity, affecting water color and clarity. Measures in Alternative 1 would actually improve reservoir storage and generally increase the quantity of water in reservoirs. Therefore, the effects of climate change from low summer flows and long-lasting droughts on visual resources would be less severe under Alternative 1 than any other alternative, including the NAA. That said, the effects of climate change and the Fall Creek Drawdown would still be major in the long term. All above-mentioned effects would be large in extent.

### *3.22.4.6 Alternative 2A. Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam)*

Under Alternative 2A, adverse effects from the construction of WTC towers, structural downstream fish passages, and AFFs would be minor in the short, medium, and long term. Potential beneficial effects from the construction of WTC towers and AFF would be minor in the long term. Drawdowns would have moderate short-term effects and major long-term, recurring effects. The extent of effects would depend on the specific dam and would be small at Lookout Point and Cougar; medium at Detroit; and large at Foster and Green Peter. The measures under this alternative would generally be consistent with the Class II, III, and IV management activities for Foster; Detroit, Fall Creek, and Green Peter; and Cougar and Lookout Point, respectively. However, long-term effects from reservoir drawdowns would not be consistent with Class III management activities at Fall Creek and Green Peter Dam and Reservoirs. Mitigation measures would be recommended to reduce the effect these measures would have to visual resources.

As discussed in 3.22.4.5, all of the major effects to visual resources would occur because of the drawdown(s), and at least one drawdown (the Fall Creek Drawdown) occurs under each alternative. Therefore, long-term, recurring effects would be major under all alternatives. Two drawdowns would occur under Alternative 2A; effects under this alternative would therefore be less severe compared to alternatives 2B, 5, 3A, and 3B; and would be more severe compared to Alternatives 1 and 4.

#### *3.22.4.6.1 Construction of WTC Towers, Structural Downstream Fish Passages, and AFFs*

Under Alternative 2A, the construction of a large concrete WTC tower would occur at Detroit Dam. Construction of structural downstream fish passages in the forms of a FSS and a Floating Surface Collector (FSC) would occur at Detroit Dam and Cougar Dam, and Lookout Point Dam, respectively. The construction of a structural downstream fish passage in the form of a modification to the existing spill (fish) weir would occur at Foster Dam. The construction of an AFF would occur at Green Peter Dam.

**<u>Foster Dam and Reservoir (Class II)</u>**

As discussed above in Section 3.22.4.3.1 (Construction of WTC Towers, Structural Downstream Fish Passages, and AFFs), potential adverse short- and long-term permanent effects would occur from the construction of the structural downstream fish passage in the form of a modification to the existing spill (fish) weir and would be minor in magnitude. As discussed under Alternative 1, effects would be large in extent because Foster recorded greater than 75,000 visits in FY 2019. Foster is a Class II area, meaning its objective is to retain the existing character of the landscape. Construction of the structural downstream fish passage would be consistent with Class II management activities.

**<u>Detroit and Green Peter Dams and Reservoirs (Class III)</u>**

As discussed above in Section 3.22.4.3.1 (Construction of WTC Towers, Structural Downstream Fish Passages, and AFFs), potential adverse medium- and long-term permanent effects from the construction of WTC towers, structural downstream fish passages, and AFFs would be minor in magnitude. As discussed under Alternative 1, effects would be medium in extent because Detroit recorded between 50,000 and 75,000 visits in FY 2019; and large in extent because Green Peter recorded more than 75,000 visits in FY 2019. Detroit and Green Peter are Class III areas, meaning its objective is to partially retain the existing character of the landscape. Construction of WTC towers, structural downstream fish passages, and AFFs would be consistent with Class III management activities.

**<u>Lookout Point and Cougar Dams and Reservoirs (Class IV)</u>**

As discussed above in Section 3.22.4.3.1 (Construction of WTC Towers, Structural Downstream Fish Passages, and AFFs), potential adverse medium- and long-term permanent effects from the construction of structural downstream fish passages would be minor in magnitude. As discussed under Alternative 1, effects would be small in extent because Lookout Point and Cougar both recorded less than 50,000 visits in FY 2019. Lookout Point and Cougar are Class IV areas, meaning their objective is to allow major modification of the existing character of the landscape. Construction of the structural downstream fish passages would be consistent with Class IV management activities.

*3.22.4.6.2 Reservoir Drawdowns*

Under Alternative 2A, deeper fall reservoir drawdowns to 25 feet over the ROs would occur at Green Peter Dam. The Fall Creek Drawdown would continue to recur under this alternative (and under all alternatives) and is discussed in Section 3.22.4.3.2 and 3.22.4.4.

**<u>Green Peter Dam and Reservoir (Class III)</u>**

As discussed above in Section 3.22.4.3.2, potential adverse short-term effects from sediment transport during drawdowns would be moderate in magnitude. Potential adverse long-term, recurring effects from revealed mudflats, substrate, tree stumps, and other submerged littoral zone attributes would be major in magnitude. Effects would be large in extent because Green Peter Dam and Reservoir recorded greater than 75,000 visitors in FY 2019. Green Peter is listed as a Class III area, meaning its objectives are to partially retain the existing character of the landscape. Short-term potential adverse effects from sediment transport during drawdowns would be consistent with the Class III Management Objectives. However, long-term effects from reservoir drawdowns would not be consistent with Class III management activities. Mitigation measures would be recommended to reduce the effect these measures would have to visual resources.

##### *3.22.4.6.3 Near-Term Operations*

As discussed above in Section 3.22.4.3.3, potential adverse short- or medium-term effects from near-term operations from reservoir drawdowns and delayed reservoir refills would be major in magnitude. Effects would be large in extent at Green Peter, Foster, and Fall Creek Dams and Reservoirs; and small at Lookout Point and Cougar Dams and Reservoirs. While these measures would generally be consistent with Class IV dams (Cougar and Lookout Point) management objectives, they would be inconsistent with Class II dams (Foster) and Class III dams (Green Peter and Fall Creek) management objectives, and mitigation measures would be recommended.

##### *3.22.4.6.4 Climate Change*

As discussed in Section 3.22.4.4.1, climate change would adversely affect visual resources within the WVS, including more intense wildfires, low summer flows, long-lasting droughts, earthen dams cracking and drying, and HABs which would alter the basic design elements of the characteristic landscape.

As described under Alternative 1, effects to the visual landscape due to the presence of construction vehicles and the erection of these new structures would not be exacerbated by climate change. The effects of climate change and the construction measures/the new structures would still be minor in the medium and long term.

Effects from the drawdowns at Fall Creek and Green Peter would be moderate in the short term and major in the long term. As described under the NAA, climate change could exacerbate short-term effects from sediment transport during drawdowns; the effects of climate change and the drawdowns would be moderate to major in the short term. Climate change could also exacerbate long-term, recurring effects from drawdowns and further change the basic design elements of color, texture, and form. If reservoir levels are already lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity; affecting water color and clarity. As such, climate change and the drawdowns would further exacerbate the already major and long-term, recurring effects. All above-mentioned effects would be large in extent.

#### ***3.22.4.7 Alternative 2B. Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)***

Under Alternative 2B, the effects to visual resources would be nearly the same as those described under Alternative 2A. The following occur under both alternatives 2A and 2B and are already discussed in Sections 3.22.4.6.1 and 3.22.4.6.2: The construction of a WTC tower at Detroit Dam; the construction of structural downstream fish passages at Detroit, Lookout Point, and Foster; construction of an AFF at Green Peter; and reservoir drawdowns at Fall Creek and Green Peter. The difference between Alternative 2B and 2A would be that the structural downstream fish passage would not be constructed at Cougar under Alternative 2B; and deeper fall reservoir drawdowns and spring reservoir drawdowns would also occur at Cougar under Alternative 2B. Potential adverse effects from the construction of WTC towers, structural downstream fish passages, and AFFs would be minor in the short, medium, and long term. Potential beneficial effects from the construction of WTC towers and AFF would be minor in the long-term and permanent. Drawdowns at Fall Creek, Green Peter, and Cougar would have moderate short-term effects and major long-term, recurring effects. The extent of effects would depend on the specific dam and would be small at Lookout Point and Cougar; medium at Detroit; and large at Foster and Green Peter. The measures under this alternative would generally be consistent with the Class II, III, and IV management activities for Foster, Detroit and Green Peter, and Cougar and Lookout Point, respectively. However, long-term effects from reservoir drawdowns would not be consistent with Class III management activities at Fall Creek and Green Peter. Mitigation measures would be recommended to reduce the effect these measures would have to visual resources.

As discussed in Section 3.22.4.5, all of the major effects to visual resources would occur because of the drawdown(s), and at least one drawdown (the Fall Creek Drawdown) occurs under each alternative. Therefore, long-term, recurring effects would be major under all alternatives. Four drawdowns would occur under Alternative 2B (and Alternative 5), compared to the one drawdown under the NAA and alternatives 1 and 4, two drawdowns under Alternative 2A; and 10 drawdowns under alternatives 3A and 3B. As such, Alternative 2B would have the same effect as Alternative 5; would be less severe compared to alternatives 3A and 3B; and would be more severe compared to alternatives 1, 2A, and 4.

#### *3.22.4.7.1 Reservoir Drawdowns*

Under Alternative 2B (and under all alternatives), the Fall Creek Drawdown would continue to recur and is discussed in Section 3.22.4.3.2 and 3.22.4.4. Deeper fall reservoir drawdowns would also occur at Green Peter Dam, and are described in Section 3.22.4.6.2. Alternative 2B would also include deeper fall reservoir drawdowns and spring reservoir drawdowns to 25 feet over the top of the diversion tunnel at Cougar Dam.

**Cougar Dam and Reservoir (Class IV)**

As discussed above in Section 3.22.4.3.2, potential adverse short-term effects from sediment transport during drawdowns would be moderate in magnitude. Potential adverse long-term, recurring effects would be major in magnitude. Effects would be small in extent because Cougar Dam and Reservoir recorded less than 50,000 visitors in FY 2019. It should be noted that drawdowns to the diversion tunnel at Cougar Dam would require dam modifications, consisting of gate structures, a tower, and a bridge that connects the tower to the edge of the reservoir. These additional modifications would drastically alter the basic design elements of the landscape, but would contribute to the overall major effect that reservoir drawdowns would already have at Cougar. Cougar is listed as a Class IV area, meaning its objectives are to allow major modification of the existing character of the landscape. Reservoir drawdowns would be consistent with Class IV management activities.

#### *3.22.4.7.2 Near-Term Operations*

As discussed above in Section 3.22.4.3.3, potential adverse short- or medium-term effects from near-term operations from reservoir drawdowns and delayed reservoir refills would be major in magnitude. Effects would be large in extent at Green Peter, Foster, and Fall Creek Dams and Reservoirs; and small at Lookout Point and Cougar Dams and Reservoirs. While these measures would generally be consistent with Class IV dams (Cougar and Lookout Point), they would be inconsistent with Class II dams (Foster) and Class III dams (Green Peter and Fall Creek) and mitigation measures would be recommended.

#### *3.22.4.7.3 Climate Change*

As discussed in Section 3.22.4.4.1, climate change would adversely affect visual resources within the WVS, including more intense wildfires, low summer flows, long-lasting droughts, earthen dams cracking and drying, and HABs which would alter the basic design elements of the characteristic landscape.

As described under alternatives 1 and 2A, effects to the visual landscape due to the presence of construction vehicles and the erection of new structures would not be exacerbated by climate change. The effects of climate change and the construction measures/the new structures would still be minor in the medium and long term.

Effects from the drawdowns at Fall Creek, Green Peter, and Cougar would be moderate in the short term and major in the long term. As described under the NAA and alternatives 1 and 2A, climate change could exacerbate short-term effects from sediment transport during drawdowns; the effects of climate change and the drawdowns would be moderate to major in the short term. Climate change could also exacerbate long-term, recurring effects from drawdowns and further change the basic design elements of color, texture, and form. If reservoir levels are already lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity; affecting water color and clarity. As such, climate change and the drawdowns would further exacerbate the already major and long-term, recurring effects. Effects would be large in extent at Green Peter and Fall Creek and small at Cougar.

### ***3.22.4.8 Alternative 3A. Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)***

Under Alternative 3A, adverse effects from the construction of AFFs would be **minor** in magnitude in the medium and long term. Potential beneficial effects from the construction of AFFs would be minor in the long term. Drawdowns would have moderate short-term and major long-term, recurring effects. The extent of effects would depend on the specific dam and would be small at Blue River, Hills Creek, Lookout Point, and Cougar Dams; medium at Detroit; and large at Fall Creek and Green Peter. The measures under this alternative would generally be consistent with the Class III and IV management activities for Detroit and Green Peter, and

Cougar, Lookout Point, Blue River, and Hills Creek, respectively. However, long-term effects from reservoir drawdowns would not be consistent with Class III management activities at Fall Creek, Detroit and Green Peter Dams and Reservoirs. Mitigation measures would be recommended to reduce the effect these measures would have to visual resources.

As discussed in Sections 3.22.4.5, all of the major effects to visual resources would occur because of the drawdown(s), and at least one drawdown (the Fall Creek Drawdown) occurs under each alternative. Therefore, long-term, recurring effects would be major under all alternatives. Ten drawdowns would occur across seven reservoirs per year under Alternative 3A (and Alternative 3B) and be a main component of these alternatives, compared to the one drawdown under the NAA, Alternative 1, and Alternative 4; two drawdowns under Alternative 2A; and four drawdowns under alternatives 2B and 5. As such, Alternative 3A (and 3B, discussed below) would have the most severe adverse effects to visual resources compared to other alternatives.

#### *3.22.4.8.1 Construction of AFFs*

Under Alternative 3A, the construction of AFFs would occur at Hills Creek Dam, Blue River Dam, and Green Peter Dam.

**Green Peter Dam and Reservoir (Class III)**

As discussed above in Section 3.22.4.3.1 (Construction of WTC Towers, Structural Downstream Fish Passages, and AFFs), potential adverse medium- and long-term permanent effects from the construction of a new AFF would be minor in magnitude. As discussed under Alternatives 1 and 2, effects would be large in extent because Green Peter recorded greater than 75,000 visits in FY 2019. Green Peter is listed as a Class III area, meaning its objectives are to partially retain the existing character of the landscape. Construction of the AFF would be consistent with the Class III management activities.

**Blue River and Hills Creek Dams and Reservoirs (Class IV)**

At Blue River and Hills Creek Dams, the AFFs would be located next to the existing dams. As discussed above in Section 3.22.4.3.1 (Construction of WTC Towers, Structural Downstream Fish Passages, and AFFs), potential adverse medium- and long-term permanent effects from the construction of AFFs would be minor in magnitude. Effects would be small in extent because Blue River and Hills Creek recorded less than 50,000 visits in FY 2019. Blue River and Hills Creek are listed as Class IV areas, meaning its objectives are to allow major modification of the existing character of the landscape. Construction of the AFFs would be consistent with the Class IV management activities.

#### *3.22.4.8.2 Reservoir Drawdowns*

Under Alternative 3A, deeper fall reservoir drawdowns to 10 feet over the ROs would occur at Lookout Point Dam, Hills Creek Dam, Cougar Dam, Blue River Dam, Green Peter Dam, and

Detroit Dam. Spring reservoir drawdowns to 10 feet over the ROs would occur at Lookout Point Dam, Cougar Dam, and Detroit Dam. The Fall Creek Drawdown would continue to recur under this alternative (and under all alternatives) and is discussed in Section 3.22.4.3.2 and 3.22.4.4.

**Detroit and Green Peter Dams and Reservoirs (Class III)**

As discussed above in Section 3.22.4.3.2, potential adverse short-term effects from sediment transport during drawdowns would have moderate effects on visual resources. Potential adverse long-term, recurring effects from revealed mudflats, substrate, tree stumps, and other submerged littoral zone attributes would be major in magnitude. Effects would be large in extent because Green Peter Dam and Reservoir recorded greater than 75,000 visitors in FY 2019; and medium in extent because Detroit Dam and Reservoir recorded between 50,000 and 75,000 visitors in FY 2019. As discussed under Alternative 2A, Green Peter and Detroit are Class III areas. As such, short-term adverse effects would be consistent with the Class III Management Objectives; but long-term effects would not be. Mitigation measures would be recommended to reduce the effect these measures would have to visual resources.

**Blue River, Hills Creek, Lookout Point, and Cougar Dams and Reservoirs (Class IV)**

As discussed above in Section 3.22.4.3.2, potential adverse short-term effects from sediment transport during drawdowns would be moderate in magnitude. Potential adverse long-term, recurring effects would be major in magnitude. Effects would be small in extent because Blue River, Hills Creek, Lookout Point, and Cougar Dams and Reservoirs recorded less than 50,000 visitors in FY 2019. Blue River, Hills Creek, Lookout Point, and Cougar are listed as Class IV areas, meaning its objectives are to allow major modification of the existing character of the landscape. Reservoir drawdowns would be consistent with Class IV management activities.

#### *3.22.4.8.3 Near-Term Operations*

As discussed above in Section 3.22.4.3.3, potential adverse short- or medium-term effects from near-term operations from reservoir drawdowns and delayed reservoir refills would be major in magnitude. Effects would be large in extent at Green Peter, Foster, and Fall Creek Dams and Reservoirs; and small at Lookout Point and Cougar Dams and Reservoirs. While these measures would generally be consistent with Class IV dams (Cougar and Lookout Point), they would be inconsistent with Class II dams (Foster) and Class III dams (Green Peter and Fall Creek) and mitigation measures would be recommended.

#### *3.22.4.8.4 Climate Change*

As discussed in Section 3.22.4.4.1, climate change would adversely affect visual resources within the WVS, including more intense wildfires, low summer flows, long-lasting droughts, earthen dams cracking and drying, and HABs which would alter the basic design elements of the characteristic landscape.

As described under alternatives 1, 2A, and 2B, effects to the visual landscape due to the presence of construction vehicles and the erection of new structures would not be exacerbated by climate change. The effects of climate change and the construction measures/the new structures would still be minor in the medium and long term.

Effects from the drawdowns at Fall Creek, Green Peter, Detroit, Blue River, Hills Creek, Lookout Point, and Cougar would be moderate in the short term and major in the long term. As described under the NAA and alternatives 1, 2A, and 2B, climate change could exacerbate short-term effects from sediment transport during drawdowns; the effects of climate change and the drawdowns would be moderate to major in the short term. Climate change could also exacerbate long-term, recurring effects from drawdowns and further change the basic design elements of color, texture, and form. If reservoir levels are already lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity; affecting water color and clarity. As such, climate change and the drawdowns would further exacerbate the already major and long-term, recurring effects. The extent of effects would be small at Blue River, Hills Creek, Lookout Point, and Cougar Dams; medium at Detroit; and large at Green Peter and Fall Creek.

#### *3.22.4.9 Alternative 3B. Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Under Alternative 3B, the effects to visual resources would be nearly the same as those described under Alternative 3A. The following occur under both alternatives 3A and 3B and are already discussed in Sections 3.22.4.8.1 and 3.22.4.8.2: The construction of AFFs at Hills Creek, Blue River, and Green Peter; fall reservoir drawdowns at Fall Creek, Lookout Point, Hills Creek, Cougar, Blue River, Green Peter, and Detroit; and spring reservoir drawdowns at Cougar. The difference between Alternative 3B and 3A is that spring reservoir drawdowns would occur at Green Peter, similar to Alternative 2A, and Hills Creek under Alternative 3B instead of Detroit and Lookout Point under Alternative 3A. In addition, Cougar would be drafted down to 25 feet over the top of the diversion tunnel, similar to Alternative 2B. Potential adverse effects from the construction of AFFs would be minor in the medium- and long-term and permanent. Potential beneficial effects from the construction of AFFs would be minor in the long term. Drawdowns would have moderate short-term and major long-term, recurring effects. The extent of effects would depend on the specific dam and would be small at Blue River, Hills Creek, Lookout Point, and Cougar Dams; medium at Detroit; and large at Fall Creek and Green Peter. The measures under this alternative would generally be consistent with the respective Class management activities as they were under Alternative 3A; though again reservoir drawdowns would be inconsistent with Class III management activities at Fall Creek, Detroit and Green Peter. Alternative 3B (and 3A, discussed above) would have the most severe adverse effects to visual resources compared to other alternatives.

As discussed in Section 3.22.4.5, all of the major effects to visual resources would occur because of the drawdown(s), and at least one drawdown (the Fall Creek Drawdown) occurs under each alternative. Therefore, long-term, recurring effects would be major under all alternatives. Ten drawdowns would occur across seven reservoirs per year under Alternative 3B (and Alternative 3A) and be a main component of these alternatives, compared to the one drawdown under the NAA, Alternative 1, and Alternative 4; two drawdowns under Alternative 2A; and four drawdowns under alternatives 2B and 5. As such, Alternative 3B (and 3A, discussed above) would have the most severe adverse effects to visual resources compared to other alternatives.

#### *3.22.4.9.1 Near-Term Operations*

As discussed above in Section 3.22.4.3.3, potential adverse short- or medium-term effects from near-term operations from reservoir drawdowns and delayed reservoir refills would be major in magnitude. Effects would be large in extent at Green Peter, Foster, and Fall Creek Dams and Reservoirs; and small at Lookout Point and Cougar Dams and Reservoirs. While these measures would generally be consistent with Class IV dams (Cougar and Lookout Point), they would be inconsistent with Class II dams (Foster) and Class III dams (Green Peter and Fall Creek) and mitigation measures would be recommended.

#### *3.22.4.9.2 Climate Change*

As discussed in Section 3.22.4.4.1, climate change would adversely affect visual resources within the WVS, including more intense wildfires, low summer flows, long-lasting droughts, earthen dams cracking and drying, and HABs which would alter the basic design elements of the characteristic landscape.

As described under alternatives 1, 2A, 2B, and 3A, effects to the visual landscape due to the presence of construction vehicles and the erection of new structures would not be exacerbated by climate change. The effects of climate change and the construction measures/the new structures would still be minor in the medium and long term.

Effects from the drawdowns at Fall Creek, Green Peter, Detroit, Blue River, Hills Creek, Lookout Point, and Cougar would be moderate in the short term and major in the long term. As described under the NAA and alternatives 1, 2A, 2B, and 3A, climate change could exacerbate short-term effects from sediment transport during drawdowns; the effects of climate change and the drawdowns would be moderate to major in the short term. Climate change could also exacerbate long-term, recurring effects from drawdowns and further change the basic design elements of color, texture, and form. If reservoir levels are already lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity; affecting water color and clarity. As such, climate change and the drawdowns would further exacerbate the already major and long-term, recurring effects. The extent of effects would be small at Blue River, Hills Creek, Lookout Point, and Cougar Dams; medium at Detroit; and large at Green Peter and Fall Creek.

### *3.22.4.10 Alternative 4. Improve Fish Passage with Structures-Based Approach*

Under Alternative 4, the effects to visual resources would be nearly the same as those described under Alternative 1. The following occur under both alternatives 1 and 4 and are already discussed in Section 3.22.4.5.1: The construction of WTC towers at Detroit and Lookout Point and the construction of structural downstream fish passages at Detroit, Lookout Point, and Foster. The difference between Alternative 4 and 1 is that a WTC tower and AFF would be constructed at Hills Creek under Alternative 4 instead of Green Peter under Alternative 1; and structural downstream fish passages would be constructed at Cougar, similar to Alternative 2A, and Hills Creek under Alternative 4 instead of Green Peter under Alternative 1. Potential adverse effects from the construction of WTC towers, AFFs, and structural downstream fish passages would be minor in magnitude in the short, medium, and long term. Potential beneficial effects from the construction of WTC towers and AFFs would be minor in the long term. The extent of effects would be large at Foster; medium at Detroit; and small at Lookout Point, Hills Creek, and Cougar Dams. The measures under this alternative would be consistent with the respective Class management activities as they were under Alternative 1.

Furthermore, as discussed in Section 3.22.4.3.2 (Fall Creek Drawdown, Deeper Fall Reservoir Drawdowns for Fish Passage, and Spring Reservoir Drawdowns for Downstream Fish Passage) and in Section 3.22.4.4 (NAA), reservoir drawdowns at Fall Creek would also continue to have moderate short-term effects and major long-term, recurring effects. Short-term effects would be consistent with Class III management objectives, but long-term effects would not, and mitigation measures would be recommended to reduce the effect these measures would have to visual resources.

As discussed in Section 3.22.4.5, all of the major effects to visual resources would occur because of the drawdown(s), and at least one drawdown (the Fall Creek Drawdown) occurs under each alternative. One drawdown would occur under the NAA, Alternative 1, and Alternative 4; and the magnitude of effects would be major under these alternatives. However, the major effects under Alternative 4 (and the NAA and Alternative 1), with the fewest number of drawdowns, would be less severe than the major effects under alternatives 3A and 3B that have the most drawdowns. Alternative 4 would have the same effect as Alternative 1, and would be less severe compared to alternatives 2A, 2B, 3A, 3B, and 5.

#### *3.22.4.10.1 Construction of WTC Towers, Structural Downstream Fish Passages, and AFFs*

Under Alternative 4, the construction of a large concrete WTC tower, structural downstream fish passage in the form of a FFS, and an AFF would occur at Hills Creek Dam.

**Hills Creek Dam and Reservoir (Class IV)**

At Hills Creek Dam, the WTC tower, structural downstream fish passage, and AFF would be located next to the existing dam. As discussed above in Section 3.22.4.3.1 (Construction of WTC Towers, Structural Downstream Fish Passages, and AFFs), potential adverse medium- and long-term permanent effects from the construction of WTC tower and structural downstream fish passage at Hills Creek Dam would be minor in magnitude. Effects would be small in extent because Hills Creek Dam and Reservoir recorded less than 50,000 visits in FY 2019. Hills Creek is a Class IV area, meaning its objective is to allow major modification of the existing character of the landscape. Construction of the WTC tower, structural downstream fish passage, and AFF would be consistent with Class IV management activities.

##### *3.22.4.10.2 Near-Term Operations*

As discussed above in Section 3.22.4.3.3, potential adverse short- or medium-term effects from near-term operations from reservoir drawdowns and delayed reservoir refills would be major in magnitude. Effects would be large in extent at Green Peter, Foster, and Fall Creek Dams and Reservoirs; and small at Lookout Point and Cougar Dams and Reservoirs. While these measures would generally be consistent with Class IV dams (Cougar and Lookout Point), they would be inconsistent with Class II dams (Foster) and Class III dams (Green Peter and Fall Creek) and mitigation measures would be recommended.

##### *3.22.4.10.3 Climate Change*

As discussed in Section 3.22.4.4.1, climate change would adversely affect visual resources within the WVS, including more intense wildfires, low summer flows, long-lasting droughts, earthen dams cracking and drying, and HABs which would alter the basic design elements of the characteristic landscape.

As described under Alternative 1, effects to the visual landscape due to the presence of construction vehicles and the erection of new structures would not be exacerbated by climate change. The effects of climate change and the construction measures/the new structures would still be minor in the medium and long term.

As described under the NAA and Alternative 1, effects from the Fall Creek Drawdown would be moderate in the short term and major in the long term. Climate change could exacerbate short-term effects from sediment transport during drawdowns; the effects of climate change and the drawdowns would be moderate to major in the short term. Climate change could also exacerbate long-term, recurring effects from drawdowns and further change the basic design elements of color, texture, and form. If reservoir levels are already lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity; affecting water color and clarity. As such, climate change and the drawdowns would further exacerbate the already major and long-term, recurring effects. Effects would be large in extent at Fall Creek.

#### ***3.22.4.11 Alternative 5. Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)***

Under Alternative 5, the effects to visual resources would be the same as those described under Alternative 2B. The following are the same in alternatives 2B and 5 and are already discussed in Sections 3.22.4.6.1, 3.22.4.6.2, and 3.22.4.7.1: The construction of a WTC tower at

Detroit; the construction of structural downstream fish passages at Detroit, Lookout Point, and Foster; the construction of an AFF at Green Peter; fall reservoir drawdowns at Fall Creek, Cougar and Green Peter; and spring reservoir drawdowns at Cougar. Potential adverse effects from the construction of WTC towers, structural downstream fish passages, and AFFs would be minor in the short, medium, and long term. Potential beneficial effects from the construction of WTC towers and AFF would be minor in the long-term and permanent. Drawdowns would have moderate short-term effects and major long-term, recurring effects. The extent of effects would depend on the specific dam and would be small at Lookout Point and Cougar; medium at Detroit; and large at Fall Creek, Foster and Green Peter. The measures under this alternative would generally be consistent with the Class II, III, and IV management activities for Foster, Detroit and Green Peter, and Cougar and Lookout Point, respectively. However, long-term effects from reservoir drawdowns would not be consistent with Class III management activities at Fall Creek and Green Peter Dams and Reservoirs. Mitigation measures would be recommended to reduce the effect these measures would have to visual resources. Alternative 5 would have the same effect as alternatives 2A and 2B; would be less severe compared to alternatives 3A and 3B; and would be more severe compared to alternatives 1 and 4.

As discussed in Section 3.22.4.5, all of the major effects to visual resources would occur because of the drawdown(s), and at least one drawdown (the Fall Creek Drawdown) occurs under each alternative. Therefore, long-term, recurring effects would be major under all alternatives. Four drawdowns would occur under Alternative 5 (and Alternative 2B), compared to the one drawdown under the NAA and alternatives 1 and 4, two drawdowns under Alternative 2A; and 10 drawdowns under alternatives 3A and 3B. As such, Alternative 5 would have the same effect as Alternative 2B; would be less severe compared to alternatives 3A and 3B; and would be more severe compared to alternatives 1, 2A, and 4.

##### *3.22.4.11.1 Near-Term Operations*

As discussed above in Section 3.22.4.3.3, potential adverse short- or medium-term effects from near-term operations from reservoir drawdowns and delayed reservoir refills would be major in magnitude. Effects would be large in extent at Green Peter, Foster, and Fall Creek Dams and Reservoirs; and small at Lookout Point and Cougar Dams and Reservoirs. While these measures would generally be consistent with Class IV dams (Cougar and Lookout Point), they would be inconsistent with Class II dams (Foster) and Class III dams (Green Peter and Fall Creek) and mitigation measures would be recommended.

##### *3.22.4.11.2 Climate Change*

As discussed in Section 3.22.4.4.1, climate change would adversely affect visual resources within the WVS, including more intense wildfires, low summer flows, long-lasting droughts, earthen dams cracking and drying, and HABs which would alter the basic design elements of the characteristic landscape.

As described under Alternative 2B, effects to the visual landscape due to the presence of construction vehicles and the erection of new structures would not be exacerbated by climate change. The effects of climate change and the construction measures/the new structures would still be minor in the medium and long term.

Effects from the drawdowns at Fall Creek, Green Peter, and Cougar would be moderate in the short term and major in the long term. As described under Alternative 2B, climate change could exacerbate short-term effects from sediment transport during drawdowns; the effects of climate change and the drawdowns would be moderate to major in the short term. Climate change could also exacerbate long-term, recurring effects from drawdowns and further change the basic design elements of color, texture, and form. If reservoir levels are already lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity; affecting water color and clarity. As such, climate change and the drawdowns would further exacerbate the already major and long-term, recurring effects. Effects would be large in extent at Green Peter and Fall Creek and small at Cougar.

#### *3.22.4.12 Conclusion*

Alternatives 2A, 2B, 3A, 3B, and 5 would include adverse moderate short-term effects, adverse minor medium-term effects, and adverse major long-term, recurring effects. Alternatives 1 and 4 would include adverse minor effects in the short, medium, and long term (permanent). All alternatives would include beneficial minor effects in the long term (permanent).

Alternatives 3A and 3B would cause the most severe adverse effects to visual resources, followed by alternatives 2A, 2B, and 5. The NAA and Alternatives 1 and 4 would cause the least severe adverse effects to visual resources. This conclusion is mostly due to the severe effect reservoir drawdowns would have on the basic elements in the characteristic landscape. Reservoir drawdowns would be a main component of alternatives 3A and 3B, with a total of 10 drawdowns across seven reservoirs per year. In contrast, alternatives 1 and 4 would consist largely of structural measures that would mostly blend into the already existing landscape of the dams and other structures and potentially provide a beneficial and visually intriguing effect to the viewshed.

## 3.23 NOISE

This section describes the existing noise environment and the potential effects of the proposed action on and from noise. Noise is considered a resource because, like physical, biological, or human resources, the noise environment can ultimately be beneficial or adverse to the welfare of humans or other desirable features of the environment, such as wildlife. An introduction to noise and noise levels is provided below. This is followed by a description of the area of analysis that would be affected by the activities described in Chapter 2. The relevant laws or regulations that govern noise are then described. The section concludes with a discussion of the sources of noise in the WVS.

### 3.23.1 Affected Environment

Noise is unwanted sound that disrupts normal activities or diminishes the quality of the environment for humans and other receptors (e.g., wildlife). Depending on the intensity and level of exposure, excessive noise could lead to a range of effects: disrupted sleep, difficulty communicating, changes in behavior, increased stress levels, and physical injury (USACE et. al., 2020). At sound levels below those that cause physiological effects, noise can reduce the aesthetic quality of the environment, especially in natural settings enjoyed by recreationists, and may affect resource integrity for tribal members engaging in cultural activities or practices (USACE et. al. 2020).

Noise traveling through air is usually expressed in decibels on the A-weighted scale (dBA), which is weighted to correspond to how humans hear sound. Table 3.23-1 provides typical noise levels in dBA from common sources that can serve as a basis for comparison of noise emissions associated with activities described in Chapter 2.

**Table 3.23-1. Common Noise Levels**

| Noise Source | Sound Level (dBA) |
|---|---|
| Night club with music | 110 |
| Pile driver | 95–101 |
| Concrete saw | 90 |
| Urban area, adjacent to freeway | 88 |
| Construction equipment, pneumatic tools | 80–85 |
| High-density urban areas | 78 |
| Urban areas | 60–65 |
| Normal conversation indoors | 60 |
| Suburban/residential areas | 45–50 |
| Rural areas | 35–40 |

Source: USACE et. al. 2020

Noise exposure depends on the amount of time an individual spends near the source and their distance from the source. To account for fluctuating sound levels, statistical descriptors have been developed for environmental noise. Exceedance levels (L levels) refer to the A-weighted sound level that is exceeded for a specified percentage of the time during a specified period. Thus, $L_{10}$ refers to a particular sound level that is exceeded 10 percent of the time (USACE et. al. 2020).

#### *3.23.1.1 Area of Analysis*

The area of analysis for the noise environment is the same as the overall area of analysis or geographic scope for this project, which is the WVS; that is, the 13 dams and reservoirs on the Willamette River and its tributaries (See Figure 1.1-2), fish hatcheries, and communities and populations within the WVS.

#### *3.23.1.2 Relevant Laws and Regulations*

The Noise Control Act of 1972 (42 USC § 4901 et seq.), as amended, has a broad goal of protecting all people from noise that jeopardizes their health or welfare. The Act further states that federal agencies are authorized and directed to further this policy to the fullest extent consistent with their authority (USACE et. al. 2020).

The Oregon Administrative Rules (OAR 340-035) specify noise limits according to the type of property where the noise would be heard (the “receiving property”). For example, hydroelectric dams are classified as industrial sources for purposes of establishing allowable noise levels at the receiving property. For such facilities, Oregon allows an $L_{50}$ noise level of 55 dBA in daytime and 50 dBA at night and $L_{10}$ of 60/55 dBA day/night (OAR 340-035). Under the Oregon regulations, construction noises are usually exempt during the day (USACE et. al. 2020).

Occupational noise is monitored and regulated in accordance with 29 CFR 1910.95, Occupational Noise Exposure. These requirements are administered by the Occupational Safety and Health Administration (OSHA) and are broadly intended to protect workers from harmful noise exposures, both in real-time and long-term.

#### *3.23.1.3 Willamette Valley System-wide Noise Environment*

Noise that is generated from the activities described in Chapter 2 occurs throughout the WVS in generally the same manner and with similar effects regardless of specific locations where the activities occur. These activities will be categorized and discussed as WVS-wide noise-generating events in the following sections that discuss heavy equipment noise, truck transport noise, light construction noise, operational noise of system facilities and equipment, and occupational noise.

For sensitive noise receptors with potential exposure to noise from projects, the likelihood of a substantial impact is greatly reduced by the inverse square law, which provides that a doubling of the distance from a noise source reduces the sound pressure level by 6 decibels. This means that noise levels listed in Table 3.23-2 are reduced by 30 decibels within 1,600 feet. In many cases, this would be sufficient to reduce noise to an acceptable level for noise sensitive receptors, but future projects that may arise within this distance should calculate and consider the noise effects. Noise emissions information that is relevant to construction activities discussed in this section, including truck transport, is presented below in Table 3.23-2.

**Table 3.23-2. Construction Equipment Noise Levels**

| Equipment | Typical Noise Level (dBA) 50 ft from Source | Distance to Reduce Noise Level to 50dBA-55dBA (feet) |
|---|---|---|
| Air Compressor | 81 | 1,600 |
| Backhoe | 80 | 1,600 |
| Ballast Equalizer | 82 | 1,600 |
| Ballast Tamper | 83 | 1,600 |
| Compactor | 82 | 1,600 |
| Concrete Mixer | 85 | 1,600 |
| Concrete Pump | 82 | 1,600 |
| Concrete Vibrator | 76 | 800 |
| Crane Mobile | 83 | 1,600 |
| Dozer | 85 | 1,600 |
| Generator | 81 | 1,600 |
| Grader | 85 | 1,600 |
| Impact Wrench | 85 | 1,600 |
| Jack Hammer | 88 | 2,400 |
| Loader | 85 | 1,600 |
| Paver | 89 | 2,600 |
| Pile Driver (Impact) | 101 | 10,600 |
| Pile Driver (Sonic) | 96 | 5,900 |
| Pneumatic Tool | 85 | 1,600 |
| Pump | 76 | 800 |
| Rail Saw | 90 | 3,000 |
| Rock Drill | 98 | 7,500 |
| Saw | 76 | 800 |
| Scraper | 89 | 2,600 |
| Shovel | 82 | 1,600 |
| Truck | 88 | 2,400 |

Source: FHWA 2021

##### *3.23.1.3.1 Heavy Equipment Noise*

Heavy equipment noise is typically characterized as noise emitted from large construction vehicles and equipment. For this analysis, and as a basis for comparison, heavy equipment noise is considered to be noise exceeding 85 dBA at 50 feet from the noise sources, and similar types of equipment, shown in Table 3.23-2 above. Operations and maintenance activities in the WVS that could generate heavy equipment noise include construction activities at dams, spillways, and fish collection facilities and modifications to the streambeds below dams or revetments.

##### *3.23.1.3.2 Truck Transport Noise*

Truck transport noise is generated by the operation of large trucks. Truck transport noise is approximately 88 dBA at 50 feet from the noise source as shown in Table 3.23-2 above. Operations and maintenance activities in the WVS that could generate truck transport noise include construction activities at dams, spillways, and fish collection facilities, fish relocation sites and transport routes, and modifications to the streambeds below dams or to revetments.

##### *3.23.1.3.3 Light Construction Equipment Noise*

The sources of light construction equipment noise are noise emissions from small/medium construction vehicles and equipment such as utility and pickup trucks, automobiles, small power tools, and hand tools. For this analysis, and as a basis for comparison, noise from light construction equipment sources is considered to be noise which does not exceed 85 dBA at 50 feet from these noise sources and similar types of smaller construction equipment to that shown in Table 3.23-2 above. Operations and maintenance activities in the WVS that could generate light construction equipment noise include minor construction activities at dams, spillways, and fish ladders and collection facilities, and modifications to the streambeds below dams or to revetments.

##### *3.23.1.3.4 Operational Noise of System Facilities and Equipment*

Operational noise associated with WVS facilities and equipment includes noise emitted from hydroelectric equipment such as turbines and generators within powerhouses. Turbine and generator noise can reach levels in excess of 100 dBA within some areas of the power house. Operations and maintenance activities in the WVS that could generate operational noise of system facilities and equipment include facility operations activities at dams, fish collection facilities, and adjacent to waterways.

##### *3.23.1.3.5 Occupational Noise*

Occupational noise can be characterized as proximate noise emissions from any of the equipment listed above that expose workers using the equipment and others close by to noise above ambient levels. This type of noise is regulated by OSHA and is most often managed through the use of worker safety and health plans or programs and/or safety manuals that accompany the specific equipment generating the noise. Operations and maintenance activities in the WVS that could generate occupational noise include both construction and operations activities at dams, spillways, and fish collection facilities, fish relocation sites and transport routes, and modifications to the streambeds below dams or to revetments.

### 3.23.2 Environmental Consequences

This section analyzes the environmental effects for the No Action Alternative and each of the action alternatives, all of which are described in Chapter 2 of this EIS. The environmental effects include both direct and indirect effects as determined by the application of the methodology described in the following section. The results of applying the methodology are presented for each alternative and are used to make an informed judgement of whether the alternative produces significant effects.

#### *3.23.2.1 Methodology*

An evaluation of environmental effects must be systematically applied to the relevant factors that apply to the resource. This analysis of the noise effects of the proposed action and alternatives began with the development of uniform evaluation criteria that could be used to present an unbiased assessment of each alternative considered. The evaluation criteria included determinations of the thresholds for magnitude, duration, and extent of the effects, which are outlined in Table 3.23-3 and summarized in the analysis section for each specific alternative.

**All comparisons of effects for each action alternative are in comparison to the NAA unless stated otherwise.**

**Table 3.23-3. Evaluation Criteria for Potential Effects from Noise**

| Effect Factors and Scale | Definition |
|---|---|
| **Magnitude** | |
| Negligible | Changes or benefits would be either nondetectable, or if detected, effects would be well below regulatory standards, as applicable. |
| Minor | Changes to the resource would be measurable, but adverse effects or benefits would be within or below regulatory standards, as applicable and would not create any incompatible land use. |
| Moderate | Changes to the resource would be measurable. Effects would be within or below regulatory standards, but historical conditions would be altered and some amount of incompatible land use may occur in undeveloped, agricultural, or low-density residential areas. Mitigation measures would be necessary and would reduce potential adverse effects. |
| Major | Changes would be readily measurable and would have substantial effects. Effects would exceed regulatory standards and a substantial |

| Effect Factors and Scale | Definition |
|---|---|
| | amount of noise exposure to incompatible land uses may occur in high density residential areas and in close proximity to noise sensitive receptors such as schools, hospitals, libraries, and other care facilities. |
| **Duration** | |
| Short-term | Alteration lasts for the duration of small construction project, and is continuous for less than 2 years. |
| Medium-term | Alteration is limited to the duration of large construction projects, and is continuous for a period of 2-5 years. |
| Long-term | Alteration is permanent or lasts continuously beyond operation changes or the completion of all construction projects; the alteration recurs at regular intervals (e.g., deep drawdowns that occur for a 3-week period in the fall and/or spring); or the alteration occurs intermittently. |
| **Extent** | |
| Small | Measurable effects confined primarily to within the site boundary |
| Medium | Measurable effects localized to areas surrounding the site |
| Large | Regional level effects – noise would be audible for several miles |

In the absence of actual measurement of sound levels for the proposed measures, the magnitude of the effects used throughout Section 3.23.2, Environmental Consequences is determined by performing a comparison with typical noise exposure levels for noise sources described in Section 3.23.1 Affected Environment.

#### *3.23.2.2 Measures Analyzed for Noise*

Measures under the action alternatives that could have an effect for noise include:

- Construct water temperature control (WTC) towers (#105)
- Construct Adult Fish Facility (#722)
- Construct Structural Downstream Fish Passage (#392)
- Gravel augmentation below dams (#384)
- Operation, maintenance, repair, replacement, and rehabilitation;
- Adapt hatchery program (#719)
- Maintenance of existing and new fish release sites above dams (#726)
- Structural Improvements to Reduce Total Dissolved Gas (#174)
- Foster Fish Ladder Temperature Improvement (#479)

- Restore Upstream and Downstream Passage at Drop Structures (#639)
- Provide Pacific Lamprey Passage and Infrastructure (#52)
- Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)

The following proposed measures would have no effect for noise, and are therefore not discussed further.

- Integrated temperature and habitat flow regime (#30a)
- Refined Integrated temperature and habitat flow regime (#30b)
- Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166)
- Use spillway for surface spill in summer (#721)
- Augment instream flows by using inactive pool (#718)
- Augment instream flows by using the power pool (#304)
- Reduce Minimum Flows to Congressionally Authorized Minimum Flow Requirements (#723)
- Deeper Fall Reservoir Drawdowns for Fish Passage (#40)
- Spring Reservoir Drawdown for Downstream Fish Passage (#720)
- Pass Water Over Spillway in Spring for Fish Passage (#714)
- Fall Creek Drawdown
- Suite of Near-term Operations Measure
- Existing Operations Continued Forward

A summary of the effects for noise discussed in the following sections is provided in Table 3.23-4. Note that the most severe magnitude of adverse effects for each alternative was listed in this table. Discussion of all adverse effects, including those that are less severe than those listing in this table, are included in the discussion below.

**Table 3.23-4. Summary of Effects for Noise Under Each Alternative**

| Effect Factor | Alternatives | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NAA | 1 | 2A | 2B | 3A | 3B | 4 | 5 |
| **Short-term** | | | | | | | | |
| Magnitude | Moderate adverse | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse | Negligible adverse |
| Extent | Small | Medium | Medium | Medium | Medium | Medium | Medium | Medium |
| **Medium-term** | | | | | | | | |
| Magnitude | None | Moderate adverse | Moderate adverse | Moderate adverse | Moderate adverse | Moderate adverse | Moderate adverse | Moderate adverse |
| Extent | None | Medium | Medium | Medium | Medium | Medium | Medium | Medium |
| **Long-term (Permanent, Intermittent, or Recurring)** | | | | | | | | |
| Magnitude | Negligible adverse | None | None | None | None | None | None | None |
| Extent | Small | None | None | None | None | None | None | None |

In the following subsections, the effects are discussed for the No Action Alternative, for the measures analyzed in the action alternatives, and for each of the action alternatives.

### ***3.23.2.3 Discussion of Effects by Measure***

This section applies the methodology described above for each measure analyzed for noise to determine the potential effect. These effects by measure will then be referenced in the action alternatives analysis that follows.

#### *3.23.2.3.1 Construct water temperature control (WTC) towers (#105); Construct adult fish facilities (AFF) (#722); Construct structural downstream fish passage (#392); Structural Improvements to reduce total dissolved gas (#174); Foster Fish Ladder Temperature Improvement (#479); Restore upstream and downstream passage at drop structures (#639); Provide Pacific lamprey passage and infrastructure (#52)*

The construction of WTC towers (#105), construction of AFFs (#722), construction of structural downstream fish passage infrastructure (#392), structural improvements for TDG (#174), the Foster Fish Ladder Temperature Improvement (#479), restoring upstream and downstream passage at drop structures (#639), and provide Pacific lamprey passage and infrastructure (#52) would involve light to heavy construction using light-duty, dump, and cement-mixing trucks; power tools; pneumatic tools; welders; and construction equipment that could possibly include dozers, backhoes, loaders, scrapers, and cranes.

Therefore, potential adverse effects from the construction of WTC towers (#105), the construction of AFFs (#722), the construction of structural downstream fish passage infrastructure (#392), structural improvements for TDG (#174), the Foster Fish Ladder Temperature Improvement (#479), restoring upstream and downstream passage at drop structures (#639), provide Pacific lamprey passage and infrastructure (#52) would be of moderate magnitude for a medium-term duration and medium extent, limited to areas immediately surrounding the construction site. There would be no long-term effects.

#### *3.23.2.3.2 Gravel augmentation below dams (#384)*

Gravel augmentation below dams (#384) would involve light construction using light-duty and dump trucks and construction equipment that could possibly include draglines, dozers, and loaders.

Therefore, potential adverse effects from gravel augmentation below dams (#384) would be of minor magnitude for a short-term duration and small extent, limited to areas immediately surrounding the augmentation site. There would be no long-term effects.

###### *3.23.2.3.3 Adapt Hatchery Program (#719) and Maintenance of Existing and New Fish Release Sites (#726)*

Noise-related effects resulting from adapting the hatchery program (#719) and maintenance of existing and new fish release sites (#726) arise from the use of tank trucks to transport adult fish from hatcheries to placement sites.

Therefore, potential adverse effects from adapting hatchery program (#719) and maintenance of existing and new fish release sites (#726) would be negligible for a short-term duration and a medium extent limited to the area of fish transport from hatcheries to placement sites. There would be no long-term effects.

###### *3.23.2.3.4 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)*

Actions to maintain or alter revetments (#9) would involve light construction using light-duty and dump trucks and construction equipment that could possibly include draglines, dozers, and loaders.

Therefore, potential adverse effects from the actions to maintain or alter revetments (#9) would be of minor magnitude for a short-term duration and small extent, limited to areas immediately surrounding the construction site. There would be no long-term effects.

###### *3.23.2.3.5 Continued Operation of Existing Adult Fish Facilities*

The magnitude of effects for continued operation of AFFs would be minor for a medium-term duration and medium extent, limited to areas immediately surrounding the construction site.

Actions for continued operation of AFFs would involve year-round routine O&M activities of the adult fish collection facilities.

Therefore, potential adverse effects for continued operation of AFFs would be of minor magnitude for a medium-term duration and medium extent, limited to areas immediately surrounding the construction site. There would be no long-term effects.

###### *3.23.2.3.6 Operation, Maintenance, Repair, Replacement and Rehabilitation*

Actions for operation, maintenance, repair, replacement and rehabilitation would involve light to heavy construction for update and repair of existing measures using trucks and construction equipment such as front-end loaders and dozers.

Therefore, potential adverse effects from the actions for operation, maintenance, repair, replacement and rehabilitation would be of minor magnitude for a medium-term duration and medium extent, limited to areas immediately surrounding the construction site. There would be no long-term effects.

#### 3.23.2.4 *No Action* Alternative

Section 2.3.1 describes current actions within the WVS and the conditions that would result from continued O&M and configuration of the WVS under existing management with no change. All ongoing, scheduled, and routine maintenance actions for the federal infrastructure and all federal structural features, including those recently constructed or that are reasonably foreseeable, are included within the NAA. Categories of actions are described in Sections 2.3.1.1 to 2.3.1.13 and they establish a baseline for ongoing effects that action alternatives will build from. These categories include flood risk management and water control, hydropower generation, electric power transmission, water quality, fish and wildlife conservation, streamflow, hatchery program, water supply, recreation, navigation, maintenance operations, coordination, and revetments and levees.

The baseline effects resulting from NAA activities have not been specifically measured and documented, but may be estimated based in part upon common noise exposure levels. Noise from activities associated with electric power transmission; water quality; fish and wildlife conservation; streamflow; water supply; and coordination would have negligible effects in the long-term and be small in extent; and would not have any short- or medium-term effects. Noise from activities associated with FRM and water control; hydropower generation; recreation would have adverse and minor effects in the long term and would be small in extent; and would not have any short- or medium-term effects. Noise from activities associated with the hatchery program; maintenance operations; and revetments and levees would have moderate and short-term effects that are small in extent; and would not have short- or medium-term effects. The analysis showed very little variation in noise effects from category-to-category and from location-to-location. Following analysis, the effects for the No Action Alternative are determined to be of negligible to moderate magnitude, short-term or long-term duration, and small or large extent. An analysis of the effects is are summarized below in Table 3.23-5.

**Table 3.23-5. Summary of Noise Effects for No Action Alternative Activities**

| No Action Alternative Categories | Noise Sources | Effects Magnitude/ Duration/Extent |
|---|---|---|
| Flood Risk Management and Water Control | Water flow through dam and/or spillway | Negligible/Long-term/Small |
| Electric Power Transmission | Transmission line noise, repair work | |
| Water Quality | Water flow through temperature control/TDG features | |
| Fish and Wildlife Conservation | Water flow for fish and wildlife management | |
| Streamflow | Water flow to manage streamflow levels | |
| Water Supply | Water flow for water supply management | |

| No Action Alternative Categories | Noise Sources | Effects Magnitude/ Duration/Extent |
|---|---|---|
| Recreation | Operate and maintain recreation facilities | |
| Navigation | Water flow to maintain navigation depths | |
| Gravel Augmentation Below Dams | Light construction using light-duty and dump trucks and construction equipment that could possibly include draglines, dozers, and loaders | Minor, Short-term, Small |
| Operation, maintenance, repair, replacement, and rehabilitation | Light to heavy construction for update and repair of existing measures using trucks and construction equipment such as front-end loaders and dozers | Minor, Medium-term, Medium |
| Hydropower Generation | Water flow through penstocks, turbines | Moderate/Long-term/Small[1] |
| Hatchery Program | Construction of hatchery production facilities | Moderate/Short-term/ Small |
| Maintenance Operations | Routine and unscheduled maintenance of facilities and structures | |
| Revetments and Levees | Clear, slope, and revet river banks<br>Construction of pile and timber bulkheads and drift barriers<br>Implement minor channel improvements and maintenance of existing works | |

[1]Noise from penstocks and turbines is attenuated by powerplant structure before reaching exterior receptors

Summarizing the data outlined in Table 3.23-5, the effects are determined to be of negligible to moderate magnitude, short-term or long-term duration, and small or large extent.

### *3.23.2.5 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Under Alternative 1, adverse effects for noise result from measures that range from Adapt hatchery program (#719) and Maintenance of existing and new fish release sites (#726), with effects that would be negligible in magnitude in the short term with a medium extent of effects, to adverse effects from measures that include WTC construction (#105), dissolved gas reduction (#174), upstream and downstream passage restoration (#639), AFF construction (#722), Pacific lamprey passage construction (#52), and structural downstream fish passage construction (#392) that would be moderate in magnitude in the medium term, with a medium extent of effects. Alternative 1 would have approximately the same effect as Alternative 4, primarily because each has the same number of proposed measures (13). There would be fewer measures for Alternatives 2A (11), 2B (11), 3A (9), and 3B (9), and 5 (11) and the noise effects would be comparatively less even though the level of each individual effect is relatively the same.

The noise effects presented in Table 3.23-6 below show little variation from location-to-location and they are of a magnitude that, while detectable, is generally not disruptive and unexpected within their surroundings. Therefore, the listed noise effects for measures implemented for multiple project locations would be uniformly applicable at each project location.

Project locations are typically removed from medium to high density land use development (e.g., residential areas), so the listed noise levels would quickly dissipate and diminish before reaching most potential noise sensitive receptors. Action locations would typically feature nearby lookout points, parks, and recreation areas, but these areas would generally be located at a distance such that noise levels, although of minor to moderate magnitude at a 50-foot distance, would quickly dissipate before reaching recreationists using these areas. Recreational opportunities are typically abundant near the project locations, and recreationists would have nearby alternatives available to them if the noise levels near the project locations are unacceptable to them. See Section 3.14 for the discussion of effects to recreation.

**Table 3.23-6. Alternative 1 Noise Effects Summary**

| Measure | Project Location | Effects Magnitude/ Duration/Extent |
|---|---|---|
| Adapt Hatchery Program (#719) | North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins | Negligible/ Short/ Medium |
| Maintenance of existing and new fish release sites above dams (#726) | North Santiam, South Santiam, South Fork McKenzie, and Middle Fork Willamette sub-basins | |
| Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) | Basin-Wide | Minor/ Short/ Small |
| Gravel augmentation below dams (#384) | North Santiam, South Santiam, and McKenzie River Basins below Big Cliff, Foster, Cougar, and Blue River dams | |
| Continued Operation of Existing Adult Fish Facilities | Foster, Fall Creek, Minto (downstream of Big Cliff), and Cougar | Minor/ Medium/ Medium |
| Operation, Maintenance, Repair, Replacement and Rehabilitation | Basin-Wide | |
| Construct water temperature control (WTC) towers (#105) | Detroit; Green Peter; Lookout Point | |

| Measure | Project Location | Effects Magnitude/ Duration/Extent |
|---|---|---|
| Structural improvements for TDG (#174) | Foster; Cougar; Detroit; Dexter; Green Peter; Lookout Point | Moderate/ Medium/ Medium |
| Foster Fish Ladder Temperature Improvement (#479) | Foster | |
| Construct structural downstream fish passage (#392) | Dexter, Lookout Point, Foster, Green Peter, Big Cliff, Detroit | |
| Restore upstream and downstream passage at drop structures (#639) | Fern Ridge | |
| Construct adult fish facility (#722) | Green Peter | |
| Provide Pacific lamprey passage and infrastructure (#52) | Fern Ridge, Green Peter | |

Summarizing the data outlined in Table 3.23-6, the effects are determined to be of negligible to moderate magnitude, short-term or medium-term duration, and small or medium extent.

#### *3.23.2.5.1 Potential Sensitive Noise Receptors*

Amongst the thirteen WVS reservoirs, nine are less developed than the others. These include Big Cliff, Blue River, Cottage Grove, Cougar, Dorena, Fall Creek, Green Peter, Hills Creek, and Lookout Point. While there are no cities directly on their shores, many have shorelines with at least some residential development. As a general observation, it would be unlikely to see sensitive noise receptors such as schools, hospitals, libraries, and medical facilities within a distance that would be impacted by project noise at these reservoirs. Future analyses that are tiered from this document should specifically consider the distance to the sensitive noise receptor so that it can be compared to the distance for meeting regulatory noise thresholds.

The other four reservoirs of Detroit, Dexter, Fern Ridge, and Foster have the towns of Detroit, Lowell, Veneta, and Sweet Home on their shores, respectively, which range from populations of 80 to 10,000. These reservoirs would continue to be slowly developed. The potential for noise exposure exists for sensitive noise receptors in these towns, as well as Lookout Point, and are noted as follows:

- Foster: this dam is located right in Sweet Home, so there would be some proximity to schools, day care facilities, and a retirement home. For example, the distance to the Foster Elementary School from the dam spillway is 0.3 miles. If a representative project noise level is assumed to be 80-85 dBA at this distance, then the noise level would be reduced to approximately 50-55 dBA within 0.3 miles, or the level of suburban/residential noise, per Table 3.23-1.

- Dexter and Lookout Point: the City of Lowell is located in between each dam and has schools and day care. There is a medical office (not a hospital) and library just south of Dexter Dam in the town of Dexter.
- Fern Ridge: there is a pre-school just east of the dam.

Wildlife species generally experience a different response to noise than humans, but as a general consideration, wildlife nearer to the project sites would experience higher sound levels and could exhibit short-term behavioral responses; depending on the season, some wildlife may avoid foraging or nesting near a project while structural measures are implemented (USACE et. al. 2020). As an example, project noise associated with construction activities adjacent to the Oregon Cascades Birding Trail at specific dams may have this effect. Black bears are also common in the area and denning bears in particular, may be sensitive to noise.

#### *3.23.2.5.2 Climate Change Effects*

As discussed in Appendix F, climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB, independent of the WVS O&M, over the next 30 years. As discussed in the land use section, these factors would contribute to changes in basin-wide land cover; however, they are less likely to result in changes to land use.

Wetter winters and drier summers would be expected to lead to changes in vegetation community composition and distribution over time, as drought tolerant species become predominant and invasive plants potentially take-over communities of native species, as discussed in Section 3.06, Vegetation. Adverse effects to land cover would occur as droughts become more frequent and severe and average summer river flows and reservoir water levels decrease. Some areas of vegetative cover could eventually transition to less desirable types of coverage (e.g., and become barren), due to the decreasing availability of water and increasing air and water temperatures. Adverse effects from droughts would become more severe over time. More severe and noticeable effects to land cover from climate change would occur as the intensity and frequency of wildfires increase. Wildfires would turn forest coverage into barren or shrub/scrub coverages immediately after a fire, and post-wildfire land cover may last for years because it could take areas decades to fully recover from wildfires, depending on the size of the fire.

To the extent that these changes in land cover result in vegetation that is sparser or barren in the case of wildfire areas, the capability to absorb noise transmission is reduced. However, the likelihood that these land cover changes occur in close proximity to proposed projects is slight. It is also true that there are no proposed measures that are dependent upon vegetation density to mitigate for substantial noise impacts. Therefore, the effects of climate change on noise would be adverse and negligible in magnitude, small in extent, and long-term.

#### *3.23.2.6 Alternative 2A. Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Structural Downstream Fish Passage at Cougar Dam)*

Under Alternative 2A, adverse effects result from measures that range from Adapt hatchery program (#719) and Maintenance of existing and new fish release sites (#726), with effects that would be negligible in magnitude in the short term with a medium extent of effects, to adverse effects from measures that include WTC construction (#105), AFF construction (#722), Pacific lamprey passage construction (#52), and structural downstream fish passage construction (#392) that would be moderate in magnitude in the medium term, with a medium extent of effects. There would be fewer measures for Alternatives 2A (11), 2B (11), 3A (9), and 3B (9), and 5 (11) and the noise effects would be comparatively less even though the level of each individual effect is relatively the same.

The noise effects presented in Table 3.23-7 below show little variation from location-to-location and they are of a magnitude that, while detectable, is generally not disruptive and unexpected within their surroundings. Therefore, the listed noise effects for measures implemented for multiple project locations would be uniformly applicable at each project location.

Project locations are typically removed from medium to high density land use development, so the listed noise levels would quickly dissipate before reaching most potential noise sensitive receptors. Project locations would typically feature nearby lookout points, parks and recreation areas, but these areas would generally be located at a distance such that noise levels, although of minor to moderate magnitude at a 50-foot distance, would quickly dissipate and diminish before reaching recreationists using these areas, Recreational opportunities are typically abundant near the project locations, and recreationists would have nearby alternatives available to them if the noise levels near the project locations are not acceptable to them.

**Table 3.23-7. Alternative 2A Noise Effects Summary**

<table>
<tr><th>Measure</th><th>Project Location</th><th>Effects Magnitude/ Duration/Extent</th></tr>
<tr><td>Adapt Hatchery Program (#719)</td><td>North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins</td><td rowspan="2">Negligible/ Short/ Medium</td></tr>
<tr><td>Maintenance of existing and new fish release sites above dams (#726)</td><td>North Santiam, South Santiam, South Fork McKenzie, and Middle Fork Willamette sub-basins</td></tr>
<tr><td>Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)</td><td>Basin-Wide</td><td>Minor/ Short/ Small</td></tr>
<tr><td>Gravel augmentation below dams (#384)</td><td>North Santiam, South Santiam, and McKenzie River Basins below Big</td><td></td></tr>
</table>

| Measure | Project Location | Effects Magnitude/ Duration/Extent |
|---|---|---|
| | Cliff, Foster, Cougar, and Blue River dams | |
| Continued Operation of Existing Adult Fish Facilities | Foster, Fall Creek, Minto (downstream of Big Cliff), and Cougar | Minor/ Medium/ Medium |
| Operation, Maintenance, Repair, Replacement and Rehabilitation | Basin-Wide | |
| Construct water temperature control tower (#105) | Detroit | Moderate/ Medium/ Medium |
| Construct Adult Fish Facility (#722) | Green Peter | |
| Provide Pacific lamprey passage and infrastructure (#52) | Green Peter | |
| Construct structural downstream fish passage (#392) | Cougar; Detroit; Foster; Lookout Point | |
| Foster Fish Ladder Temperature Improvement (#479) | Foster | |

Summarizing the data outlined in Table 3.23-7, the effects are determined to be of negligible to moderate magnitude, short-term or medium-term duration, and small or medium extent.

*3.23.2.6.1 Potential Sensitive Noise Receptors*

Amongst the thirteen WVS reservoirs, nine are less developed than the others. These include Big Cliff, Blue River, Cottage Grove, Cougar, Dorena, Fall Creek, Green Peter, Hills Creek, and Lookout Point. While there are no cities directly on their shores, many have shorelines with at least some residential development. As a general observation, it would be unlikely to see sensitive noise receptors such as schools, hospitals, libraries, and medical facilities within a distance that would be impacted by project noise at these reservoirs.

The other four reservoirs of Detroit, Dexter, Fern Ridge, and Foster have the towns of Detroit, Lowell, Veneta, and Sweet Home on their shores, respectively, which range from populations of 80 to 10,000. These reservoirs would continue to be slowly developed. The potential for noise exposure exists for sensitive noise receptors in these towns, as well as Lookout Point, and are noted as follows:

- Foster: this dam is located right in Sweet Home, so there would be some proximity to schools, day care facilities, and a retirement home. For example, the distance to the Foster Elementary School from the dam spillway is 0.3 miles. If a representative project noise level is assumed to be 80-85 dBA at this distance, then the noise level would be reduced to approximately 50-55 dBA within 0.3 miles, or the level of suburban/residential noise, per Table 3.23-1.

- Dexter and Lookout Point: the City of Lowell is located in between each dam and has schools and day care. There is a medical office (not a hospital) and library just south of Dexter Dam in the town of Dexter.
- Fern Ridge: there is a pre-school just east of the dam.

For those sensitive noise receptors with potential exposure to noise from projects, the likelihood of a substantial impact is greatly reduced by the inverse square law, which provides that a doubling of the distance from a noise source reduces the sound pressure level by 6 decibels. In a practical sense, this means that noise levels at fifty feet listed in Table 3.23-2 are reduced by 30 decibels within 800 feet. In most cases, this would be sufficient to reduce noise to an acceptable level for noise sensitive receptors, but future projects that may arise within this distance should calculate and consider the noise effects.

Wildlife generally experience a different response to noise than humans, but as a general consideration, wildlife nearer to the project sites would experience higher sound levels and could exhibit short-term behavioral responses; depending on the season, some wildlife may avoid foraging or nesting near a project while structural measures are implemented (USACE et. al. 2020). As an example, project noise associated with construction activities adjacent to the Oregon Cascades Birding Trail at specific dams may have this effect. Black bears are also common in the area and denning bears in particular, may be sensitive to noise.

#### *3.23.2.6.2 Climate Change Effects*

As discussed in Appendix F, climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB, independent of the WVS O&M, over the next 30 years. As discussed in the land use section, these factors would contribute to changes in basin-wide land cover; however, they are less likely to result in changes to land use.

Wetter winters and drier summers would be expected to lead to changes in vegetation community composition and distribution over time, as drought tolerant species become predominant and invasive plants potentially take-over communities of native species, as discussed in Section 3.06, Vegetation. Adverse effects to land cover would occur as droughts become more frequent and severe and average summer river flows and reservoir water levels decrease. Some areas of vegetative cover could eventually transition to less desirable types of coverage (e.g., and become barren), due to the decreasing availability of water and increasing air and water temperatures. Adverse effects from droughts would become more severe over time. More severe and noticeable effects to land cover from climate change would occur as the intensity and frequency of wildfires increase. Wildfires would turn forest coverage into barren or shrub/scrub coverages immediately after a fire, and post-wildfire land cover may last for years because it could take areas decades to fully recover from wildfires, depending on the size of the fire.

To the extent that these changes in land cover result in vegetation that is sparser or barren in the case of wildfire areas, the capability to absorb noise transmission is reduced. However, the likelihood that these land cover changes occur in close proximity to proposed projects is slight. It is also true that there are no proposed measures that are dependent upon vegetation density to mitigate for substantial noise impacts. Therefore, the effects of climate change on noise would be adverse and negligible in magnitude, small in extent, and long-term.

#### *3.23.2.7 Alternative 2B. Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Under Alternative 2B, adverse effects result from measures that range from Adapt hatchery program (#719) and Maintenance of existing and new fish release sites (#726), with effects that would be negligible in magnitude in the short term with a medium extent of effects, to adverse effects from measures that include WTC construction (#105), AFF construction (#722), Pacific lamprey passage construction (#52), and structural downstream fish passage construction (#392) that would be moderate in magnitude in the medium term, with a medium extent of effects. There would be fewer measures for Alternatives 2A (11), 2B (11), 3A (9), and 3B (9), and 5 (11) and the noise effects would be comparatively less even though the level of each individual effect is relatively the same.

The noise effects presented in Table 3.23-8 below show little variation from location-to-location and they are of a magnitude that, while detectable, is not disruptive and unexpected within their surroundings. Therefore, the listed noise effects for measures implemented for multiple project locations would be uniformly applicable at each project location.

Project locations are typically removed from medium to high density land use development, so the listed noise levels would quickly dissipate before reaching most potential noise sensitive receptors. Project locations would typically feature nearby viewpoints, parks, and recreation areas, but these areas would generally be located at a distance such that noise levels, although of minor to moderate magnitude at a 50-foot distance, would quickly dissipate before reaching recreationists using these areas. Recreational opportunities are typically abundant near the project locations, and recreationists would have nearby alternatives available to them if the noise levels near the project locations are not acceptable to them.

**Table 3.23-8. Alternative 2B Noise Effects Summary**

| Measure | Project Location | Effects Magnitude/ Duration/Extent |
|---|---|---|
| Adapt Hatchery Program (#719) | North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins | Negligible/ Short/ Medium |
| Maintenance of existing and new fish release sites above dams (#726) | North Santiam, South Santiam, South Fork McKenzie, and Middle Fork Willamette sub-basins | |
| Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) | Basin-Wide | Minor/ Short/ Small |
| Gravel augmentation below dams (#384) | North Santiam, South Santiam, and McKenzie River Basins below Big Cliff, Foster, Cougar, and Blue River dams | |
| Continued Operation of Existing Adult Fish Facilities | Foster, Fall Creek, Minto (downstream of Big Cliff), and Cougar | Minor/ Medium/ Medium |
| Operation, Maintenance, Repair, Replacement and Rehabilitation | Basin-Wide | |
| Construct water temperature control tower (#105) | Detroit | Moderate/ Medium/ Medium |
| Construct adult fish facility (#722) | Green Peter | |
| Provide Pacific lamprey passage and infrastructure (#52) | Green Peter | |
| Construct structural downstream fish passage (#392) | Detroit; Foster; Lookout Point | |
| Foster Fish Ladder Temperature Improvement (#479) | Foster | |

Summarizing the data outlined in Table 3.23-8, the effects are determined to be of negligible to moderate magnitude, short-term or medium-term duration, and small or medium extent.

### *3.23.2.7.1 Potential Sensitive Noise Receptors*

Amongst the thirteen WVS reservoirs, nine are less developed than the others. These include Big Cliff, Blue River, Cottage Grove, Cougar, Dorena, Fall Creek, Green Peter, Hills Creek, and Lookout Point. While there are no cities directly on their shores, many have shorelines with at least some residential development. As a general observation, it would be unlikely to see sensitive noise receptors such as schools, hospitals, libraries, and medical facilities within a distance that would be impacted by project noise at these reservoirs.

The other four reservoirs of Detroit, Dexter, Fern Ridge, and Foster have the towns of Detroit, Lowell, Veneta, and Sweet Home on their shores, respectively, which range from populations of 80 to 10,000. These reservoirs would continue to be slowly developed. The potential for noise exposure exists for sensitive noise receptors in these towns, as well as Lookout Point, and are noted as follows:

- Foster: this dam is located right in Sweet Home, so there would be some proximity to schools, day care facilities, and a retirement home. For example, the distance to the Foster Elementary School from the dam spillway is 0.3 miles. If a representative project noise level is assumed to be 80-85 dBA at this distance, then the noise level would be reduced to approximately 50-55 dBA within 0.3 miles, or the level of suburban/residential noise, per Table 3.23-1.
- Dexter and Lookout Point: the City of Lowell is located in between each dam and has schools and day care. There is a medical office (not a hospital) and library just south of Dexter Dam in the town of Dexter.
- Fern Ridge: there is a pre-school just east of the dam.

For those sensitive noise receptors with potential exposure to noise from projects, the likelihood of a substantial impact is greatly reduced by the inverse square law, which provides that a doubling of the distance from a noise source reduces the sound pressure level by 6 decibels. In a practical sense, this means that noise levels at fifty feet listed in Table 3.23-2 are reduced by 30 decibels within 800 feet. In most cases, this would be sufficient to reduce noise to an acceptable level for noise sensitive receptors, but future projects that may arise within this distance should calculate and consider the noise effects.

Wildlife generally experience a different response to noise than humans, but as a general consideration, wildlife nearer to the project sites would experience higher sound levels and could exhibit short-term behavioral responses; depending on the season, some wildlife may avoid foraging or nesting near a project while structural measures are implemented (USACE et. al. 2020). As an example, project noise associated with construction activities adjacent to the Oregon Cascades Birding Trail at specific dams may have this effect. Black bears are also common in the area and denning bears in particular, may be sensitive to noise.

##### *3.23.2.7.2 Climate Change Effects*

As discussed in Appendix F, climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB, independent of the WVS O&M, over the next 30 years. As discussed in the land use section, these factors would contribute to changes in basin-wide land cover; however, they are less likely to result in changes to land use.

Wetter winters and drier summers would be expected to lead to changes in vegetation community composition and distribution over time, as drought tolerant species become predominant and invasive plants potentially take-over communities of native species, as discussed in Section 3.06, Vegetation. Adverse effects to land cover would occur as droughts become more frequent and severe and average summer river flows and reservoir water levels decrease. Some areas of vegetative cover could eventually transition to less desirable types of coverage (e.g., and become barren), due to the decreasing availability of water and increasing air and water temperatures. Adverse effects from droughts would become more severe over time. More severe and noticeable effects to land cover from climate change would occur as the intensity and frequency of wildfires increase. Wildfires would turn forest coverage into barren or shrub/scrub coverages immediately after a fire, and post-wildfire land cover may last for years because it could take areas decades to fully recover from wildfires, depending on the size of the fire.

To the extent that these changes in land cover result in vegetation that is sparser or barren in the case of wildfire areas, the capability to absorb noise transmission is reduced. However, the likelihood that these land cover changes occur in close proximity to proposed projects is slight. It is also true that there are no proposed measures that are dependent upon vegetation density to mitigate for substantial noise impacts. Therefore, the effects of climate change on noise would be adverse and negligible in magnitude, small in extent, and long-term.

#### *3.23.2.8 Alternative 3A – Operations-Focused Fish Passage Alternative*

Under Alternative 3A, adverse effects result from measures that range from Adapt hatchery program (#719) and Maintenance of existing and new fish release sites (#726), with effects that would be negligible in magnitude in the short term with a medium extent of effects, to adverse effects from measures that include AFF construction (#722) and Pacific lamprey passage construction (#52) that would be moderate in magnitude in the medium term, with a medium extent of effects. There would be fewer measures for Alternatives 2A (11), 2B (11), 3A (9), and 3B (9), and 5 (11) and the noise effects would be comparatively less even though the level of each individual effect is relatively the same.

The noise effects presented in Table 3.23-9 below show little variation from location-to-location and they are of a magnitude that, while detectable, is not disruptive and unexpected within their surroundings. Therefore, the listed noise effects for measures implemented for multiple project locations would be uniformly applicable at each project location.

Project locations are typically removed from medium to high density land use development, so the listed noise levels would quickly dissipate before reaching most potential noise sensitive receptors. Project locations would typically feature nearby lookout points, parks and recreation areas, but these areas would typically be located at a distance such that noise levels, although of minor to moderate magnitude at a 50-foot distance, would quickly dissipate before reaching recreationists using these areas. Recreational opportunities are typically abundant near the project locations, and recreationists would have nearby alternatives available to them if the noise levels near the project locations are not acceptable to them.

**Table 3.23-9. Alternative 3A Noise Effects Summary**

| Measure | Project Location | Effects Magnitude/ Duration/ Extent |
|---|---|---|
| Adapt hatchery program (#719) | North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins | Negligible/ Short/ Medium |
| Maintenance of existing and new fish release sites above dams (#726) | North Santiam, South Santiam, South Fork McKenzie, and Middle Fork Willamette sub-basins | |
| Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) | Basin-Wide | Minor/ Short/ Small |
| Gravel augmentation below dams (#384) | North Santiam, South Santiam, and McKenzie River Basins below Big Cliff, Foster, Cougar, and Blue River dams | |
| Continued Operation of Existing Adult Fish Facilities | Foster, Fall Creek, Minto (downstream of Big Cliff), and Cougar | Minor/ Medium/ Medium |
| Operation, Maintenance, Repair, Replacement and Rehabilitation | Basin-Wide | |
| Construct adult fish facility (#722) | Blue River; Green Peter; Hills Creek | Moderate/ Medium/ Medium |
| Provide Pacific lamprey passage and infrastructure (#52) | Blue River; Green Peter; Hills Creek | |

Summarizing the data outlined in Table 3.23-9, the effects are determined to be of negligible to moderate magnitude, short-term or medium-term duration, and small or medium extent.

*3.23.2.8.1 Potential Sensitive Noise Receptors*

Amongst the thirteen WVS reservoirs, nine are less developed than the others. These include Big Cliff, Blue River, Cottage Grove, Cougar, Dorena, Fall Creek, Green Peter, Hills Creek, and Lookout Point. While there are no cities directly on their shores, many have shorelines with at least some residential development. As a general observation, it would be unlikely to see sensitive noise receptors such as schools, hospitals, libraries, and medical facilities within a distance that would be impacted by project noise at these reservoirs.

The other four reservoirs of Detroit, Dexter, Fern Ridge, and Foster have the towns of Detroit, Lowell, Veneta, and Sweet Home on their shores, respectively, which range from populations of 80 to 10,000. These reservoirs would continue to be slowly developed. The potential for noise exposure exists for sensitive noise receptors in these towns, as well as Lookout Point, and are noted as follows:

- Foster: this dam is located right in Sweet Home, so there would be some proximity to schools, day care facilities, and a retirement home. For example, the distance to the Foster Elementary School from the dam spillway is 0.3 miles. If a representative project noise level is assumed to be 80-85 dBA at this distance, then the noise level would be reduced to approximately 50-55 dBA within 0.3 miles, or the level of suburban/residential noise, per Table 3.23-1.
- Dexter and Lookout Point: the City of Lowell is located in between each dam and has schools and day care. There is a medical office (not a hospital) and library just south of Dexter Dam in the town of Dexter.
- Fern Ridge: there is a pre-school just east of the dam.

For those sensitive noise receptors with potential exposure to noise from projects, the likelihood of a substantial impact is greatly reduced by the inverse square law, which provides that a doubling of the distance from a noise source reduces the sound pressure level by 6 decibels. In a practical sense, this means that noise levels at fifty feet listed in Table 3.23-2 are reduced by 30 decibels within 800 feet. In most cases, this would be sufficient to reduce noise to an acceptable level for noise sensitive receptors, but future projects that may arise within this distance should calculate and consider the noise effects.

Wildlife generally experience a different response to noise than humans, but as a general consideration, wildlife nearer to the project sites would experience higher sound levels and could exhibit short-term behavioral responses; depending on the season, some wildlife may avoid foraging or nesting near a project while structural measures are implemented (USACE et. al. 2020). As an example, project noise associated with construction activities adjacent to the Oregon Cascades Birding Trail at specific dams may have this effect. Black bears are also common in the area and denning bears in particular, may be sensitive to noise.

##### *3.23.2.8.2 Climate Change Effects*

As discussed in Appendix F, climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB, independent of the WVS O&M, over the next 30 years. As discussed in the land use section, these factors would contribute to changes in basin-wide land cover; however, they are less likely to result in changes to land use.

Wetter winters and drier summers would be expected to lead to changes in vegetation community composition and distribution over time, as drought tolerant species become predominant and invasive plants potentially take-over communities of native species, as discussed in Section 3.06, Vegetation. Adverse effects to land cover would occur as droughts become more frequent and severe and average summer river flows and reservoir water levels decrease. Some areas of vegetative cover could eventually transition to less desirable types of coverage (e.g., and become barren), due to the decreasing availability of water and increasing air and water temperatures. Adverse effects from droughts would become more severe over time. More severe and noticeable effects to land cover from climate change would occur as the intensity and frequency of wildfires increase. Wildfires would turn forest coverage into barren or shrub/scrub coverages immediately after a fire, and post-wildfire land cover may last for years because it could take areas decades to fully recover from wildfires, depending on the size of the fire.

To the extent that these changes in land cover result in vegetation that is sparser or barren in the case of wildfire areas, the capability to absorb noise transmission is reduced. However, the likelihood that these land cover changes occur in close proximity to proposed projects is slight. It is also true that there are no proposed measures that are dependent upon vegetation density to mitigate for substantial noise impacts. Therefore, the effects of climate change on noise would be adverse and negligible in magnitude, small in extent, and long-term.

#### *3.23.2.9 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at COU)*

Under Alternative 3B, adverse effects result from measures that range from Adapt hatchery program (#719) and Maintenance of existing and new fish release sites (#726), with effects that would be negligible in magnitude in the short term with a medium extent of effects, to adverse effects from measures that include AFF construction (#722) and Pacific lamprey passage construction (#52) that would be moderate in magnitude in the medium term, with a medium extent of effects. There would be fewer measures for Alternatives 2A (11), 2B (11), 3A (9), and 3B (9), and 5 (11) and the noise effects would be comparatively less even though the level of each individual effect is relatively the same.

The noise effects presented in Table 3.23-10 below show little variation from location-to-location and they are of a magnitude that, while detectable, is not disruptive and unexpected within their surroundings. Therefore, the listed noise effects for measures implemented for multiple project locations would be uniformly applicable at each project location.

Project locations are typically removed from medium to high density land use development, so the listed noise levels would quickly dissipate before reaching most potential noise sensitive receptors. Project locations would typically feature nearby viewpoints, parks, and recreation areas, but these areas would typically be located at a distance such that noise levels, although of minor to moderate magnitude at a 50-foot distance, would quickly dissipate before reaching recreationists using these areas. Recreational opportunities are typically abundant near the project locations, and recreationists would have nearby alternatives available to them if the noise levels near the project locations are not acceptable to them.

**Table 3.23-10. Alternative 3B Noise Effects Summary**

| Measure | Project Location | Effects Magnitude/ Duration/ Extent |
|---|---|---|
| Adapt Hatchery Program (#719) | North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins | Negligible/ Short/ Medium |
| Maintenance of existing and new fish release sites above dams (#726) | North Santiam, South Santiam, South Fork McKenzie, and Middle Fork Willamette sub-basins | |
| Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) | Basin-Wide | Minor/ Short/ Small |
| Gravel augmentation below dams (#384) | North Santiam, South Santiam, and McKenzie River Basins below Big Cliff, Foster, Cougar, and Blue River dams | |
| Continued Operation of Existing Adult Fish Facilities | Foster, Fall Creek, Minto (downstream of Big Cliff), and Cougar | Minor/ Medium/ Medium |
| Operation, Maintenance, Repair, Replacement and Rehabilitation | Basin-Wide | |
| Construct adult fish facility (#722) | Blue River; Green Peter; Hills Creek | Moderate/ Medium/ Medium |
| Provide Pacific lamprey passage and infrastructure (#52) | Blue River; Green Peter; Hills Creek | |

Summarizing the data outlined in Table 3.23-10, the effects are determined to be of negligible to moderate magnitude, short-term or medium-term duration, and small or medium extent.

*3.23.2.9.1 Potential Sensitive Noise Receptors*

Amongst the thirteen WVS reservoirs, nine are less developed than the others. These include Big Cliff, Blue River, Cottage Grove, Cougar, Dorena, Fall Creek, Green Peter, Hills Creek, and Lookout Point. While there are no cities directly on their shores, many have shorelines with at least some residential development. As a general observation, it would be unlikely to see sensitive noise receptors such as schools, hospitals, libraries, and medical facilities within a distance that would be impacted by project noise at these reservoirs.

The other four reservoirs of Detroit, Dexter, Fern Ridge, and Foster have the towns of Detroit, Lowell, Veneta, and Sweet Home on their shores, respectively, which range from populations of 80 to 10,000. These reservoirs would continue to be slowly developed. The potential for noise exposure exists for sensitive noise receptors in these towns, as well as Lookout Point, and are noted as follows:

- Foster: this dam is located right in Sweet Home, so there would be some proximity to schools, day care facilities, and a retirement home. For example, the distance to the Foster Elementary School from the dam spillway is 0.3 miles. If a representative project noise level is assumed to be 80-85 dBA at this distance, then the noise level would be reduced to approximately 50-55 dBA within 0.3 miles, or the level of suburban/residential noise, per Table 3.23-1.
- Dexter and Lookout Point: the City of Lowell is located in between each dam and has schools and day care. There is a medical office (not a hospital) and library just south of Dexter Dam in the town of Dexter.
- Fern Ridge: there is a pre-school just east of the dam.

For those sensitive noise receptors with potential exposure to noise from projects, the likelihood of a substantial impact is greatly reduced by the inverse square law, which provides that a doubling of the distance from a noise source reduces the sound pressure level by 6 decibels. In a practical sense, this means that noise levels at fifty feet listed in Table 3.23-2 are reduced by 30 decibels within 800 feet. In most cases, this would be sufficient to reduce noise to an acceptable level for noise sensitive receptors, but future projects that may arise within this distance should calculate and consider the noise effects.

Wildlife generally experience a different response to noise than humans, but as a general consideration, wildlife nearer to the project sites would experience higher sound levels and could exhibit short-term behavioral responses; depending on the season, some wildlife may avoid foraging or nesting near a project while structural measures are implemented (USACE et. al. 2020). As an example, project noise associated with construction activities adjacent to the Oregon Cascades Birding Trail at specific dams may have this effect. Black bears are also common in the area and denning bears in particular, may be sensitive to noise.

#### *3.23.2.9.2 Climate Change Effects*

As discussed in Appendix F, climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB, independent of the WVS O&M, over the next 30 years. As discussed in the land use section, these factors would contribute to changes in basin-wide land cover; however, they are less likely to result in changes to land use.

Wetter winters and drier summers would be expected to lead to changes in vegetation community composition and distribution over time, as drought tolerant species become predominant and invasive plants potentially take-over communities of native species, as discussed in Section 3.06, Vegetation. Adverse effects to land cover would occur as droughts become more frequent and severe and average summer river flows and reservoir water levels decrease. Some areas of vegetative cover could eventually transition to less desirable types of coverage (e.g., and become barren), due to the decreasing availability of water and increasing air and water temperatures. Adverse effects from droughts would become more severe over time. More severe and noticeable effects to land cover from climate change would occur as the intensity and frequency of wildfires increase. Wildfires would turn forest coverage into barren or shrub/scrub coverages immediately after a fire, and post-wildfire land cover may last for years because it could take areas decades to fully recover from wildfires, depending on the size of the fire.

To the extent that these changes in land cover result in vegetation that is sparser or barren in the case of wildfire areas, the capability to absorb noise transmission is reduced. However, the likelihood that these land cover changes occur in close proximity to proposed projects is slight. It is also true that there are no proposed measures that are dependent upon vegetation density to mitigate for substantial noise impacts. Therefore, the effects of climate change on noise would be adverse and negligible in magnitude, small in extent, and long-term.

### *3.23.2.10 Alternative 4 – Structures-Based Fish Passage Alternative*

Under Alternative 4, adverse effects result from measures that range from Adapt hatchery program (#719) and Maintenance of existing and new fish release sites (#726), with effects that would be negligible in magnitude in the short term with a medium extent of effects, to adverse effects from measures that include WTC tower construction (#105), total dissolved gas reduction (#174), upstream and downstream passage restoration (#639), AFF construction (#722), structural downstream fish passage construction (#392), and Pacific lamprey passage construction (#52) that would be moderate in magnitude in the medium term, with a medium extent of effects. Alternative 1 would have approximately the same, most adverse effect as Alternative 4 primarily because each has the same, greatest number of proposed measures (13). There would be fewer measures for Alternatives 2A (11), 2B (11), 3A (9), and 3B (9), and 5 (11) and the noise effects would be comparatively less even though the level of each individual effect is relatively the same.

The noise effects presented in Table 3.23-11 below show little variation from location-to-location and they are of a magnitude that, while detectable, is not disruptive and unexpected within their surroundings. Therefore, the listed noise effects for measures implemented for multiple project locations would be uniformly applicable at each project location.

Project locations are typically removed from medium to high density land use development, so the listed noise levels would quickly dissipate before reaching most potential noise sensitive receptors. Project locations would typically feature nearby lookout points, parks and recreation areas, but these areas would typically be located at a distance such that noise levels, although of minor to moderate magnitude at a 50-foot distance, would quickly dissipate before reaching recreationists using these areas. Recreational opportunities are typically abundant near the project locations, and recreationists would have nearby alternatives available to them if the noise levels near the project locations are not acceptable to them.

**Table 3.23-11. Alternative 4 Noise Effects Summary**

| Measure | Project Location | Effects Magnitude/ Duration/ Extent |
|---|---|---|
| Adapt Hatchery Program (#719) | North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins | Negligible/ Short/ Medium |
| Maintenance of existing and new fish release sites above dams (#726) | North Santiam, South Santiam, South Fork McKenzie, and Middle Fork Willamette sub-basins | |
| Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) | Basin-Wide | Minor/ Short/ Small |
| Gravel augmentation below dams (#384) | North Santiam, South Santiam, and McKenzie River Basins below Big Cliff, Foster, Cougar, and Blue River | |
| Continued Operation of Existing Adult Fish Facilities | Foster, Fall Creek, Minto (downstream of Big Cliff), and Cougar | Minor/ Medium/ Medium |
| Operation, Maintenance, Repair, Replacement and Rehabilitation | Basin-Wide | |
| Construct water temperature control tower (#105) | Detroit; Hills Creek; Lookout Point | Moderate/ Medium/ Medium |
| Structural improvements to reduce TDG (#174) | Cougar; Detroit; Dexter; Foster; Green Peter; Lookout Point | |
| Foster Fish Ladder Temperature Improvement (#479) | Foster | |
| Restore upstream and downstream passage at drop structures (#639) | Fern Ridge | |
| Construct adult fish facility (#722) | Hills Creek | |
| Provide Pacific lamprey passage and infrastructure (#52) | Fern Ridge; Hills Creek | |
| Construct structural downstream fish passage (#392) | Cougar; Detroit; Foster; Hills Creek; Lookout Point | |

Summarizing the data outlined in Table 3.23-11, the effects are determined to be of negligible to moderate magnitude, short-term or medium-term duration, and small or medium extent.

#### *3.23.2.10.1 Potential Sensitive Noise Receptors*

Amongst the thirteen WVS reservoirs, nine are less developed than the others. These include Big Cliff, Blue River, Cottage Grove, Cougar, Dorena, Fall Creek, Green Peter, Hills Creek, and Lookout Point. While there are no cities directly on their shores, many have shorelines with at least some residential development. As a general observation, it would be unlikely to see sensitive noise receptors such as schools, hospitals, libraries, and medical facilities within a distance that would be impacted by project noise at these reservoirs.

The other four reservoirs of Detroit, Dexter, Fern Ridge, and Foster have the towns of Detroit, Lowell, Veneta, and Sweet Home on their shores, respectively, which range from populations of 80 to 10,000. These reservoirs would continue to be slowly developed. The potential for noise exposure exists for sensitive noise receptors in these towns, as well as Lookout Point, and are noted as follows:

- Foster: this dam is located right in Sweet Home, so there would be some proximity to schools, day care facilities, and a retirement home. For example, the distance to the Foster Elementary School from the dam spillway is 0.3 miles. If a representative project noise level is assumed to be 80-85 dBA at this distance, then the noise level would be reduced to approximately 50-55 dBA within 0.3 miles, or the level of suburban/residential noise, per Table 3.23-1.
- Dexter and Lookout Point: the City of Lowell is located in between each dam and has schools and day care. There is a medical office (not a hospital) and library just south of Dexter Dam in the town of Dexter.
- Fern Ridge: there is a pre-school just east of the dam.

For those sensitive noise receptors with potential exposure to noise from projects, the likelihood of a substantial impact is greatly reduced by the inverse square law, which provides that a doubling of the distance from a noise source reduces the sound pressure level by 6 decibels. In a practical sense, this means that noise levels at fifty feet listed in Table 3.23-2 are reduced by 30 decibels within 800 feet. In most cases, this would be sufficient to reduce noise to an acceptable level for noise sensitive receptors, but future projects that may arise within this distance should calculate and consider the noise effects.

Wildlife generally experience a different response to noise than humans, but as a general consideration, wildlife nearer to the project sites would experience higher sound levels and could exhibit short-term behavioral responses; depending on the season, some wildlife may avoid foraging or nesting near a project while structural measures are implemented (USACE et. al. 2020). As an example, project noise associated with construction activities adjacent to the Oregon Cascades Birding Trail at specific dams may have this effect. Black bears are also common in the area and denning bears in particular, may be sensitive to noise.

#### *3.23.2.10.2 Climate Change Effects*

As discussed in Appendix F, climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB, independent of the WVS O&M, over the next 30 years. As discussed in the land use section, these factors would contribute to changes in basin-wide land cover; however, they are less likely to result in changes to land use.

Wetter winters and drier summers would be expected to lead to changes in vegetation community composition and distribution over time, as drought tolerant species become predominant and invasive plants potentially take-over communities of native species, as discussed in Section 3.06, Vegetation. Adverse effects to land cover would occur as droughts become more frequent and severe and average summer river flows and reservoir water levels decrease. Some areas of vegetative cover could eventually transition to less desirable types of coverage (e.g., and become barren), due to the decreasing availability of water and increasing air and water temperatures. Adverse effects from droughts would become more severe over time. More severe and noticeable effects to land cover from climate change would occur as the intensity and frequency of wildfires increase. Wildfires would turn forest coverage into barren or shrub/scrub coverages immediately after a fire, and post-wildfire land cover may last for years because it could take areas decades to fully recover from wildfires, depending on the size of the fire.

To the extent that these changes in land cover result in vegetation that is sparser or barren in the case of wildfire areas, the capability to absorb noise transmission is reduced. However, the likelihood that these land cover changes occur in close proximity to proposed projects is slight. It is also true that there are no proposed measures that are dependent upon vegetation density to mitigate for substantial noise impacts. Therefore, the effects of climate change on noise would be adverse and negligible in magnitude, small in extent, and long-term.

### ***3.23.2.11 Alternative 5. Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)***

Under Alternative 5, adverse effects result from measures that range from Adapt hatchery program (#719) and Maintenance of existing and new fish release sites (#726), with effects that would be negligible in magnitude in the short term with a medium extent of effects, to adverse effects from measures that include WTC construction (#105), AFF construction (#722), Pacific lamprey passage construction (#52), and structural downstream fish passage construction (#392) that would be moderate in magnitude in the medium term, with a medium extent of effects. Alternative 1 would have approximately the same effect as Alternative 4 primarily because each has the same number of proposed measures (13). There would be fewer measures for Alternatives 2A (11), 2B (11), 3A (9), and 3B (9), and 5 (11) and the noise effects would be comparatively less even though the level of each individual effect is relatively the same.

The noise effects presented in Table 3.23-12 below show little variation from location-to-location and they are of a magnitude that, while detectable, is not disruptive and unexpected within their surroundings. Therefore, the listed noise effects for measures implemented for multiple project locations would be uniformly applicable at each project location.

Project locations are typically removed from medium to high density land use development, so the listed noise levels would quickly dissipate before reaching most potential noise sensitive receptors. Project locations would typically feature nearby lookout points, parks and recreation areas, but these areas would typically be located at a distance such that noise levels, although of minor to moderate magnitude at a 50-foot distance, would quickly dissipate before reaching recreationists using these areas, Recreational opportunities are typically abundant near the project locations, and recreationists would have nearby alternatives available to them if the noise levels near the project locations are not acceptable to them.

**Table 3.23-12. Alternative 5 Noise Effects Summary**

| Measure | Project Location | Effects Magnitude/ Duration/Extent |
|---|---|---|
| Adapt Hatchery Program (#719) | North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins | Negligible/ Short/ Medium |
| Maintenance of existing and new fish release sites above dams (#726) | North Santiam, South Santiam, South Fork McKenzie, and Middle Fork Willamette sub-basins | |
| Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9) | Basin-Wide | Minor/ Short/ Small |
| Gravel augmentation below dams (#384) | North Santiam, South Santiam, and McKenzie River Basins below Big Cliff, Foster, Cougar, and Blue River dams | |
| Continued Operation of Existing Adult Fish Facilities | Foster, Fall Creek, Minto (downstream of Big Cliff), and Cougar | Minor/ Medium/ Medium |
| Operation, Maintenance, Repair, Replacement and Rehabilitation | Basin-Wide | |
| Construct water temperature control tower (#105) | Detroit | Moderate/ Medium/ Medium |
| Construct adult fish facility (#722) | Green Peter | |
| Provide Pacific lamprey passage and infrastructure (#52) | Green Peter | |

| Measure | Project Location | Effects Magnitude/ Duration/Extent |
|---|---|---|
| Construct structural downstream fish passage (#392) | Detroit; Foster; Lookout Point | |
| Foster Fish Ladder Temperature Improvement (#479) | Foster | |

Summarizing the data outlined in Table 3.23-12, the effects are determined to be of negligible to moderate magnitude, short-term or medium-term duration, and small or medium extent.

*3.23.2.11.1 Potential Sensitive Noise Receptors*

Amongst the thirteen WVS reservoirs, nine are less developed than the others. These include Big Cliff, Blue River, Cottage Grove, Cougar, Dorena, Fall Creek, Green Peter, Hills Creek, and Lookout Point. While there are no cities directly on their shores, many have shorelines with at least some residential development. As a general observation, it would be unlikely to see sensitive noise receptors such as schools, hospitals, libraries, and medical facilities within a distance that would be impacted by project noise at these reservoirs.

The other four reservoirs of Detroit, Dexter, Fern Ridge, and Foster have the towns of Detroit, Lowell, Veneta, and Sweet Home on their shores, respectively, which range from populations of 80 to 10,000. These reservoirs would continue to be slowly developed. The potential for noise exposure exists for sensitive noise receptors in these towns, as well as Lookout Point, and are noted as follows:

- Foster: this dam is located right in Sweet Home, so there would be some proximity to schools, day care facilities, and a retirement home. For example, the distance to the Foster Elementary School from the dam spillway is 0.3 miles. If a representative project noise level is assumed to be 80-85 dBA at this distance, then the noise level would be reduced to approximately 50-55 dBA within 0.3 miles, or the level of suburban/residential noise, per Table 3.23-1.
- Dexter and Lookout Point: the City of Lowell is located in between each dam and has schools and day care. There is a medical office (not a hospital) and library just south of Dexter Dam in the town of Dexter.
- Fern Ridge: there is a pre-school just east of the dam.

For those sensitive noise receptors with potential exposure to noise from projects, the likelihood of a substantial impact is greatly reduced by the inverse square law, which provides that a doubling of the distance from a noise source reduces the sound pressure level by 6 decibels. In a practical sense, this means that noise levels at fifty feet listed in Table 3.23-2 are reduced by 30 decibels within 800 feet. In most cases, this would be sufficient to reduce noise to an acceptable level for noise sensitive receptors, but future projects that may arise within this distance should calculate and consider the noise effects.

Wildlife generally experience a different response to noise than humans, but as a general consideration, wildlife nearer to the project sites would experience higher sound levels and could exhibit short-term behavioral responses; depending on the season, some wildlife may avoid foraging or nesting near a project while structural measures are implemented (USACE et. al. 2020). As an example, project noise associated with construction activities adjacent to the Oregon Cascades Birding Trail at specific dams may have this effect. Black bears are also common in the area and denning bears in particular, may be sensitive to noise.

#### *3.23.2.11.2 Climate Change Effects*

As discussed in Appendix F, climate change is expected to result in wetter winters, drier summers, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB, independent of the WVS O&M, over the next 30 years. As discussed in the land use section, these factors would contribute to changes in basin-wide land cover; however, they are less likely to result in changes to land use.

Wetter winters and drier summers would be expected to lead to changes in vegetation community composition and distribution over time, as drought tolerant species become predominant and invasive plants potentially take-over communities of native species, as discussed in Section 3.06, Vegetation. Adverse effects to land cover would occur as droughts become more frequent and severe and average summer river flows and reservoir water levels decrease. Some areas of vegetative cover could eventually transition to less desirable types of coverage (e.g., and become barren), due to the decreasing availability of water and increasing air and water temperatures. Adverse effects from droughts would become more severe over time. More severe and noticeable effects to land cover from climate change would occur as the intensity and frequency of wildfires increase. Wildfires would turn forest coverage into barren or shrub/scrub coverages immediately after a fire, and post-wildfire land cover may last for years because it could take areas decades to fully recover from wildfires, depending on the size of the fire.

The transmission of noise between a source and receptor is reduced by absorption or deflection of sound waves by solid intervening barriers, with the amount of reduction determined by the density of the intervening barrier. Some barriers such as walls beside highways are constructed of dense materials for the purpose of noise reduction. Natural vegetation may also reduce noise transmission, although the density of such a barrier would be less than walls beside highways. To the extent that climate-induced changes in land cover result in vegetation that is sparser or barren in the case of wildfire areas, the capability to absorb noise transmission is reduced. However, the degree to which these land cover changes occur near proposed projects is indeterminate. It is also true that there are no specific proposed measures having effects that are dependent upon vegetation density to mitigate for substantial noise impacts. Therefore, the effects of climate change on noise would be adverse and negligible in magnitude, small in extent, and long-term.

## 3.24 TRIBAL RESOURCES

The definition of tribal resources is multifaceted and dependent on the circumstance that requires the characterization. For the purposes of this EIS, tribal resources include lands and resources defined as Indian Trust Assets (ITAs), treaty and reserved rights that occur on and off Indian trust lands, and the lands and resources that are in the ancestral territories and usual and accustomed places of tribes but are now owned by the federal government.

Due to the unique relationship between federally recognized Indian tribes and the U.S. federal government, which is based on nearly 250 years of treaties, case law, federal statute, and executive orders, the federal government has a legal “trust responsibility” to ensure that it supports tribal self-governance, economic prosperity, access to treaty resources, and rights of access and use of natural and cultural resources on ancestral lands. This trust doctrine is part and parcel to the treaties that serve as the foundation for tribal legal standing as domestic sovereign nations. Indian tribes ceded millions of acres of tribal lands to the federal government, between 1798 and 1871, in return for much smaller land reservations and the federal government guaranteed rights, assets, and support to ensure the well-being and continuance of Indian tribes. The reserved lands were located in undesirable or less desirable locations like the outer edges or outside of the Willamette Valley.

During the reservation era, lawmakers developed a system to place these tribal lands and resources in the care of the federal government. The federal government came to hold these tribal resources “in trust” for Indian tribes. These assets that belong to tribes but are held in trust by the federal government are Indian Trust Assets (ITAs). In this legal relationship, the federal government acts as a trustee of assets for the tribe, or beneficiary. There is a fiduciary responsibility on behalf of the federal government to ensure that those assets are managed for the benefit of Indian tribes or individuals.

ITAs can include reserved tribal lands, minerals on trust lands, and hunting, fishing, and gathering rights typically on trust lands, and water rights that can be on or off tribal lands (U.S. DOI n.d.a, n.d.b; U.S. DHHS n.d.; Tsosie 2003). Treaty and reserved rights are another component of tribal resources. During the treaty-signing era, Indian tribes granted lands and rights to the federal government while explicitly retaining certain rights (as written in the treaties), but they also retained or reserved those rights not expressly granted to the federal government.

In November 2021, the Advisory Council on Historic Preservation, the Department of Defense (which oversees the Corps), the Department of the Interior, the White House Council on Environmental Quality, and 12 other departments and independent agencies executed the *Memorandum of Understanding regarding Interagency Coordination and Collaboration for the Protection of Tribal Treaty Rights and Reserved Rights* (ACHP et al., 2021). Through this document, the signatory agencies stated:

> Treaty-protected rights to use of and access to natural and cultural resources are an intrinsic part of tribal life and are of deep cultural, economic, and subsistence

> importance to tribes. Many treaties protect not only the right to access natural resources, such as fisheries, but also protect the resource itself from significant degradation. Under the U.S. Constitution, treaties are part of the supreme law of the land, with the same legal force and effect as federal statutes. Pursuant to this principle, and its trust relationship with federally recognized tribes, the United States has an obligation to honor the rights reserved through treaties, including rights to both on and, where applicable, off-reservation resources, and to ensure that its actions are consistent with those rights and their attendant protections. Accordingly, the Parties recognize the need to consider and account for the effects of their actions on the habitats that support treaty-protected rights.
>
> The Supreme Court has explained that Indian treaties are to be interpreted liberally in favor of tribes, giving effect to the treaty terms as tribes would have understood them, with ambiguous provisions interpreted for their benefit… This means that federal agencies must give effect to treaty language and ensure that federal agency actions do not conflict with tribal treaty and reserved rights.
>
> Integrating consideration of tribal treaty and reserved rights into agency decision-making and regulatory processes is consistent with the federal government's trust responsibility to federally recognized tribes and to fundamental principles of good government. Treaties themselves are the source of legal authority to ensure that agency processes account for reserved treaty rights.

The governance of ITAs is explicit because the resources in questions are only to provide benefit to Indian tribes and individuals, whereas the full expression of treaty and reserved rights off tribal trust lands can be unclear especially when these rights conflict with “public trust” and federal lands (Tsosie, 2003). The federal government owns and manages approximately 640 million acres of land (CRS, 2021; NALC, n.d.; U.S. GAO, n.d.). This is approximately 28% of the 2.7 billion acres that is the United States. Four land managing agencies oversee the majority of public lands (606.5 million acres or 95%) including the Forest Service, Fish and Wildlife Service, National Park Service, and Bureau of Land Management. The Corps also manages nearly nine million acres. Each of these agencies have a different mission statement, but the concept of public trust is that all federal agencies employ ethical management and stewardship of public lands and resources for the continued benefit of the American public. This is a major tenet of the four land-managing agencies.

Americans recreate on, have access to natural and cultural resources, and enjoy public lands per this public trust, which can directly impact how tribes can access and use treaty and reserved rights. An example of this management conflict is when recreational activities are incongruous with the management of tribal sacred sites (Tsosie, 2003).

More generally, treaty and reserved rights that are off Indian trust lands occur on public lands and are within the ancestral territories or usual and accustomed areas of tribes. For this EIS, traditional tribal lands are the third facet of tribal resources. These places are where indigenous communities lived, traveled, traded, etc. for millennia before European and Asian colonizers, explorers, and immigrants came to what is now known as the State of Oregon, in the late 16th century, and to the Willamette Valley, in the early 19th century. By their reckoning, Willamette Valley tribes have lived here since "time immemorial", and it is a historical fact that the tribes were unwillingly divested of their homelands through deceit and force. The tribes may have ceded the lands of the Willamette Valley and the majority of the State of Oregon to the federal government, but this did not sever their connection to or use of the area. It is notable that all of the major treaties signed by tribes of the Willamette Valley occurred prior to Oregon statehood of 1859 (between 1853 and 1855). The descendants of the original Willamette River Basin peoples are now represented by several federally recognized tribes, and the management of natural and cultural resources on trust lands, ancestral territories, and usual and accustomed areas are of primary concern to these tribes.

Inherent in this effects analysis is that all resources considered in the EIS are tribal resources. The health and viability of the economy, environment, and society of the Willamette Valley and connected areas are important to the individual American citizens who also belong to sovereign nations of federally recognized tribes. Federally recognized tribes with a vested interest in and deep historical connection to the Willamette Valley have reiterated this through the consultative process with the Corps on a government-to-government basis and through project-specific consultation that has and continues to occur.

Federal Indian policy of the last 50 years has moved towards supporting self-determination and prosperity for Indian tribes. In this vein, the Corps as a federal agency adheres to the following tenets:

- Tribal governments are sovereign nations, and the Corps recognizes the right of tribes to self-government;
- The Agency will work to meet trust obligations, protect trust resources, and obtain tribal views of trust and treaty responsibilities;
- The Corps leaders will meet with the leaders of tribal governments on a government to government level. The Agency recognizes that tribes have a right to be treated in accordance with the principles of self-determination;
- The Corps will collaboratively involve tribes, before and throughout the decision-making process, to ensure a timely exchange of information, to take into account disparate viewpoints, and use a fair and impartial dispute resolution process;
- The Corps will search for ways to involve tribes in programs, projects, and other activities that build the economic capacity and manage tribal resources while preserving cultural identities;
- The Corps will act to fulfill its obligations to preserve and protect trust resources and to consider the potential effects of Corps programs on natural and cultural resources (USACE, n.d.c.).

The U.S. Constitution, more than a century of case law, the following Executive Orders, and guidance documents guide Corps Tribal Policy Principles:

- Executive Order (EO) 13175, dated November 6, 2000, Consultation and Coordination with Indian Tribal Governments,
- Presidential Memorandum (PM), dated April 29, 1994, Government-to-Government Relations with Native American Tribal Governments,
- PM, dated November 5, 2009, Tribal Consultation,
- and the Office of the Secretary of Defense's Trust Responsibility and Consultation Matrix.

The Corps also complies with numerous environmental and cultural resources protection laws that require early and meaningful consultation and collaboration with tribes to identify, manage, and assess and mitigate effects to resources and lands that are important to the tribes (e.g. USACE, n.d.a, n.d.b.). Major laws include the National Environmental Policy Act of 1969, the National Historic Preservation Act of 1966, and the Native American Graves Protection and Repatriation Act, of 1990.

### 3.24.1 Methodology

The area of analysis for the tribal resources is defined broadly as the geographic boundaries of the Willamette River Basin (WRB). As noted in Chapter 1, the Willamette River is located entirely within the state of Oregon, beginning south of the community of Cottage Grove, and extending approximately 187 miles to the north where it flows into the Columbia River.

The area of analysis is derived by casting a wide net to include all of the resources considered in the EIS, and mirrors the extent used for the analysis of Fish, Aquatic Invertebrates, and Habitat (Section 3.8), which is the most expansive area of analysis for a resource. Given the importance of fish and aquatic invertebrates to tribes consulted for this EIS and for the Columbia River System Operations EIS (USACE, BOR, & BPA 2020), this is extent is reasonable. The northernmost boundary of the area of analysis for the other resources analyzed in this EIS stops at Willamette Falls in Oregon City, Oregon. This is based on the hydrological modeling which indicates that this is the most downstream point that is controlled by the WVS. Willamette Falls is a historically significant place that continues to be used by several of the WRB and Columbia River tribes that were consulted for this EIS.

The effects analysis for tribal resources has two components: 1) the assessment of the agency preparing the EIS, and 2) the views of the tribes who have a vested interest in the WRB and the potential impacts of the operations and maintenance of the WVS. The first component can be found in Chapter 3, Affected Environment and Environmental Consequences, and more specifically in the following sections Hydrological Processes (Section 3.2), River Mechanics and Geomorphology (Section 3.3), Geology (Section 3.4), Water Quality (Section 3.5), Vegetation (Section 3.6), Wetlands (Section 3.7) Fish, Aquatic Invertebrates (Section 3.8), Wildlife, Birds, and Terrestrial Habitat (Section 3.9), Air Quality (Section 3.10), Socioeconomic Resources

(Section 3.11), Power Generation and Transmission (Section 3.12), Water Supply (Section 3.13), Recreation (Section 3.14), Land Use (Section 3.15), Hazardous Materials (Section 3.16), Public Health and Safety (Sections 3.17-3.19), Environmental Justice (Section 3.20), Cultural Resources (Section 3.21), Visual Resources (Section 3.22), and Noise (Section 3.23).

Defining and documenting the second component is ongoing and will require more outreach and engagement with tribes. As will be discussed below, three tribes are participating in the EIS as cooperating agencies and have provided some comments through this process. Other tribes have provided comment on the EIS through the scoping process. The Corps has also requested a point of contact for potentially affected tribes, as well as asking them to provide written perspectives on tribal resources and the potential impacts of the operations and maintenance of the WVS on them. The tribal resources section will be updated as this consultation continues, but it is anticipated that any narratives provided by the tribes on how their interests will be impacted will be included verbatim in Appendix O, Tribal Coordination and Perspectives, and referenced, where applicable, throughout the body of the EIS.

The Corps, Bureau of Reclamation, and Bonneville Power Association recently completed the Columbia River System Operations Final Environmental Impact Analysis and issued a Record of Decision, in July and September of 2020. Those efforts included outreach to 19 federally recognized tribes including several that have interests in WRB and the WVS (USACE, BOR, & BPA 2020a, 2020b). The three agencies asked the tribes to provide information on ITAs, tribal perspectives on the impacts of the Columbia River System operations, and qualitative statements regarding tribal interests. The received responses are applicable to this EIS. Specifically, five tribes with whom the Corps is currently consulting for this EIS provided responses. The waters of the WVB feed into the Columbia River, and the WVS affects resources that also occur in the Columbia River, at least in the case of fish, aquatic invertebrates, and habitat. For other resources, the northern extent of the area of analysis terminates at Willamette Falls, an extremely significant location for several federally recognized tribes of the WRB and Columbia Plateau.

### 3.24.2 Affected Environment

The Corps has initiated consultation with ten federally recognized Indian tribes including:

- Confederated Tribes and Bands of the Yakama Nation (Yakama)
- Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians (CTCLUSI)
- Confederated Tribes of Grand Ronde Community of Oregon (Grand Ronde),
- Confederated Tribes of Siletz Indians (Siletz),
- Confederated Tribes of the Umatilla Indian Reservation (Umatilla)
- Confederated Tribes of Warm Springs (Warm Springs)
- Coquille Indian Tribe (Coquille)

- Cow Creek Band of Umpqua Tribe of Indians (Cow Creek)
- Klamath Tribes (Klamath)
- Nez Perce Tribe (Nez Perce)

In response to Corps' letters dated September 30, 2021, representatives from the CTCLUSI, Coquille, and Klamath tribes declined to consult on the EIS and deferred to other tribes. For a list of major correspondence between the Corps and tribes, see Appendix O, Tribal Coordination and Perspectives.

The Corps routinely consults with the Cow Creek, Grand Ronde, Siletz, and Warm Springs tribes for WVS actions that require NEPA review and undertakings that require National Historic Preservation Act compliance. These actions typically occur within the footprint of the 13 multipurpose dam and reservoir project areas. The Grand Ronde tribe is actively participating as a Cooperating Agency in the development of this EIS and the Corps and tribe have an MOU executed on February 28, 2020. The Siletz and Warm Springs have also participated in cooperator meetings, but have not signed an MOU with the Corps.

The Corps, in partnership with the Cow Creek, Grand Ronde, Siletz, and Warm Springs tribes, as well as several federal and state partners and other interested parties, recently executed a program-level programmatic agreement that modifies the Section 106 process to follow a streamlined and standardized approach to manage historic properties that have the potential to be impacted by Corps' undertakings related to the current and future operations of the WVS. The Corps continues to work with these partners to meet the requirements of the programmatic agreement, part of which includes drafting a historic properties management plan.

The Corps has also included four Columbia River tribes who are members of the Columbia River Inter-Tribal Fish Commission (CRITFC) and were consulted for the Columbia River System Operations EIS. These tribes include the Yakama, Umatilla, Warm Springs, and Nez Perce. CRITFC was established, in 1977, to protect fishery resources and reserved treaty rights, and "to ensure that salmon are provided the respect accorded by tribal cultural beliefs and required under law" (CRITFC, 2021a). CRITFC employs legal experts, policy analysts, law enforcement officers, technical specialists, public information specialists, etc. to act as a "champion of tribal rights and resources protection and an authoritative entity working on behalf of native fish and native people in the Columbia River Basin" (CRITFC, 2021a). The commission espouses four major goals: 1) put fish back in the rivers and protect watersheds where fish live, 2) protect tribal treaty fishing rights, 3) share salmon culture, and 4) provide fisher services (CRITFC, 2021b). Given the area of analysis for the Fish, Aquatic Invertebrates, and Habitat terminates where the Willamette River meets the Columbia River, it follows that the member tribes of CRITFC have a valid interest in the development of the WVS EIS. The Grand Ronde tribe was also consulted as part of the Columbia River System Operation EIS.

Table 3.24.1 provides a list of treaties that serve as the legal foundations that connect the seven federally recognized tribes with the Willamette Valley. The tribes have distinct but sometimes overlapping interests. Of note, for this EIS, the Grand Ronde, Siletz, and Cow Creek tend to have interests that are centered within the Willamette Valley (though interests definitely expand beyond the Willamette Valley), while the Yakama, Umatilla, and Nez Perce are centered in the Columbia Plateau. The Warm Springs have interests that extend to both the Columbia River and Willamette Valley.

**Table 3.24-1. Affected Indian Tribes and WRB-Relevant Treaties**

| Federally-Recognized Tribe(s) | Treaties |
|---|---|
| Confederated Tribes of Grand Ronde Community of Oregon | Rogue River Treaty, September 10, 1853<br><br>Treaty with Cow Creek Band of Umpqua, September 19, 1853<br><br>Rogue River Treaty, November 15, 1854<br><br>Treaty with the Chasta, Scoton, and Umpqua, November 18, 1854<br><br>Treaty with the Umpqua and Kalapuya, November 29, 1854<br><br>Willamette Valley Treaty, January 22, 1855<br><br>Treaty with the Molalla, December 21, 1855 |
| Cow Creek Band of Umpqua Tribe of Indians | Cow Creek Band of Umpqua Treaty, September 19, 1853 |
| Confederated Tribes and Bands of the Yakama Nation | Yakama Treaty, June 9, 1855 |
| Nez Perce Tribe | Nez Perce Treaty, June 11, 1855 |
| Confederated Tribes of the Umatilla Indian Reservation | Walla Walla Treaty, June 9, 1855 |
| Confederated Tribes of Warm Springs | Treaty of 1855 (also Treaty with the Tribes of Middle Oregon, June 25, 1855) |
| Confederated Tribes of Siletz Indians | Rogue River Treaty, September 10, 1853 |

One area of noticeable overlap is the historic and continued use of Willamette Falls. All of the tribes with the exception of the Cow Creek tribe, claim the falls as ceded lands or ancestral territory and continue to procure salmon and lamprey there today (CTGR, 2022B; CTUIR, 2021; CTWS, 2021b; Karson Engum, 2020; WFT, n.d.).

According to the Bureau of Indian Affairs, Division of Land Titles and Records, only the Grand Ronde and Warm Springs tribes have ITA holdings in the outer reaches of the WRB (BIA, n.d.). In the western extent of Yamhill sub-basin, the Grand Ronde tribe has a 11,500-acre reservation (CTGR, 2022A). This amount is significantly reduced from the original size of the Grand Ronde Reservation established by Executive Order, on June 30, 1857 (61,000 acres), but increased from 9,811 acres that the tribe got back through the Grand Ronde Restoration Act of November

22, 1983 (CTGR, 2022A). Through the seven treaties listed in Table 3.24-1, Grand Ronde ancestors ceded all of the Willamette Valley and beyond for a significantly reduced reserve of tribal lands. On the opposite end of the WRB, a small portion of the western boundary the Warm Springs reservation overlaps with the eastern tips of the Clackamas and North Santiam sub-basins. The reservation currently totals 644,000 acres, which is a small fraction of the 10 million acres ceded in 1855. The original treaty incorrectly provided for 464,000 acres, but this was rectified to include another 180,000 acres, in 1972, after the resolution of a longstanding boundary dispute. In each of these instances the ITA holdings are located outside of the WVS (Clackamas and Yamhill) or in the upper reaches above the WVS (North Santiam).

The concept of tribal resources, when viewed through a federal legal framework, is different than tribal understanding of tribal resources. As detailed in the Columbia River System Operations EIS, tribes who chose to provide tribal input and perspective found that federal agencies failed to understand the holistic connections between natural resources, cultural resources, and the everyday practice of tribal lifeways. This was reflected, they contended, in the agencies' adoption of a definition of "cultural resources" that focused on properties, as suggested by the National Historic Preservation Act, versus a more holistic definition of cultural resources that sees a much broader range of phenomena as cultural resources. For example, several tribes claimed that fish, which are a key part of many Native American ceremonies in the Pacific Northwest, are just as much of a cultural resource as an archaeological site or a historic building. This reliance on a property-based definition of cultural resources is just one example of how the perspective adopted by the agencies is fundamentally at odds with most indigenous peoples' learning systems (USACE, BOR, & BPA, 2020:3-1456).

For the WVS EIS, the Grand Ronde, Yakama, and CRITFC (representing the member tribes Yakama, Umatilla, Warm Springs, and Nez Perce) provided comments in the same vein as those provided for the Columbia River Operations System EIS, but CRITFC also provided comments specific to operating and maintaining the WVS that show a deep interest in fish and wildlife habitat, water quality, water allocation, and cultural resources.

In a letter dated June 2, 2020, Grand Ronde provided comments to the Corps acting in their capacity as a Cooperating Agency. The comments were specific to the alternatives and measure for the WVS EIS. The Grand Ronde requested to be involved in the development of the measures and shared concerns about the alternative development. They noted that overall we tribal staff feel that we are being given opportunities to weigh in verbally on the WVS-EIS alternatives and measures. However, much of what is presented to the Cooperating Agencies is often too vague or general to provide full and informed comments on.

Grand Ronde preferred alternatives that did not create a dichotomy of structure-focused versus operations-focused but requested that needs and feasibility be considered based on the location. The tribe further indicated that monitoring, evaluating, and adaptive management would be requirements and there should be room for interim measures rather than a long-term or no-term measure.

Grand Ronde recommended that the Corps analyze whether measures in the Coast Fork and Long Tom watersheds would benefit salmon and lamprey and noted that there are few measures that deal directly with those watersheds. One consideration should be removal or modification of the structures in the lower Long Tom (below Fern Ridge Reservoir). Grande Ronde noted that historically the Coast Fork had salmonid runs and the Long Tom had Pacific lamprey runs. The Tribe recommended fish passage measures at Dorena and Cottage Grove, and supported annual drawdowns, similar to those occurring at Fall Creek, to occur where feasible. Overall, the tribe requested that Pacific lamprey passage be considered at all of the projects. Grand Ronde also asked that structures at Detroit and Cougar be considered with the EIS rather than as standalone NEPA actions. Finally, the tribe also requested to be involved in any future water quality discussions.

In a letter dated June 28, 2019, CRITFC provide scoping comments for the operations and maintenance of the WVS on behalf of the four Columbia Plateau tribes asserting that they possess rights they reserved by treaties with the federal government to take a fair share of the fish destined to pass their usual and accustomed fishing places in the interior Columbia River basin and its tributaries. Inherent in the right to take fish is the conservation and protection of the fishery resource. These reserved rights are not geographically limited to lands ceded to the United States…federal agencies must use their authorities in a manner that will protect and enhance – not degrade – the fish species that underlie treaty fishing right. The *U.S. v. Oregon* and *U.S. v. Washington* cases also affirmed that Northwest tribes, by virtue of their treaties with the U.S. government, have co-management status on fisheries resources. In reserving the right to fish at all usual and accustomed places, tribes retained their authority to regulate the tribal fishery. State and federal government co-managers are therefore required to have meaningful consultation on actions that affect the treaty-protected fisheries resources. These actions include non-tribal fisheries, hatchery production, protection of natural spawning environment, and protection of downstream and upstream migration through the river.

CRITFC offered several recommendations to avoid and minimize impacts on the tribal fishery resources or providing concerns specific to the operations and maintenance of the WVS. These include

- CRITFC stated that “the Willamette Basin is one of the most prominent habitats for lamprey, with Willamette Falls as a significant historical fishing site…the largest proportion of lamprey in the Willamette Basin inhabit the Santiam River, a tributary that will be affected by this project. Diminished in the Columbia River, the Willamette is one of the last few basins for lamprey to thrive.” CRITFC recommends that the Corp improve issues with known adult lamprey passage, develop alternative forms of passage, and implement a research, monitoring, and evaluation plan for larval and juvenile lamprey. CRITFC also noted that upstream tributaries where larval lamprey have been observed need to be maintained for habitat and water quality.
- CRITFC is concerned that water quality impacts may result from changes in the WVS operations and how this will hurt juvenile lamprey, steelhead, and chinook salmon.

- Climate change must be considered to develop an accurate WVS EIS. CRITFC noted that changes may result in reduced water in the reservoirs, affect local flows that will make it difficult to meet BiOp targets, water temperatures may impact lamprey, steelhead, and chinook salmon.
- CRITFC "greatest concern" is the lack of live flows to meet fish and wildlife year-round BiOp requirements and Corps' ability to maintain consistent flows.
- CRITFC notes that tribal cultural resources are more than archaeological sites and that the National Historic Preservation Act and Archaeological Resources Protection Act account for historic properties of religious and cultural significance to tribes or traditional cultural properties. CRITFC identifies these as places where tribal members gather First Foods, hunt, and fish, other cultural sites where tribal members visit or use for various purposes, and salmon and lamprey and their ecosystem. CRITFC noted that the cultural resources analysis will need to involve the Yakama, Umatilla, Warm Springs, and Nez Perce.
- CRITFC recommends using spill/flow programs, seasonal/permanent drawdown, summer spill/flow operations, and altered operations for low and mid-range water years to support salmon habitat and survival. These recommendations are defined as hydro system operational changes.
- Recommended hydro system structural modifications to improve fish passage and survival through the WVS include the installation of temperature structures, surface passage structures/collectors, improvement of existing ladders for adult passage or trap and haul facilities and evaluating smolt transport options.
- CRITFC notes that a "suite of tributary and estuary mitigation actions" (off site mitigation) will support complying with the Northwest Power Act.
- CRITFC recommends that the EIS consider the effects of the WVS on reservoir ecology and how these changes would affect fish and wildlife resources.
- CRITFC asks that the EIS include metrics and data related to fish project survival, reach survival, and delayed mortality and to consider at a minimum reach, project, and SAR survival metrics and some of the modeling should not rely on the COMPASS model.

Independently of the CRITFC scoping letter, the Yakama tribe provided scoping comments in a letter, dated April 17, 2019, to state that the tribe had concerns that development for the WVS EIS could interfere with treaty reserved rights in the Yakama tribe's usual and accustomed areas. The letter further requested "meaningful technical level engagement with USACE during the NEPA process and the development of the EIS."

Table 3.24-2 provides a summary list of concerns or issues provided by the tribes through comment on the WVS EIS. It also provides WRB-specific topics and issues that the tribes describe for their own natural and cultural resources programs on tribal websites.

**Table 3.24-2. Issues that Tribes Have Identified for the WVS EIS and WRB**

| Federally-Recognized Tribe or Tribal Representative | Issues and Concerns |
|---|---|
| Confederated Tribes of Grand Ronde Community of Oregon | The Grand Ronde provided comments in 6/2/2020 noting the following:<br>The tribe wishes to be involved in measure and alternative development<br>Balance project needs to include operations and structure based measures, as needed<br>Monitoring, evaluation, and adaptive management programs<br>Consider interim measures as well as long-term and no-term in analysis<br>Analyze measures for the Coast Fork and Long Tom watersheds to salmon and lamprey<br>Long Tom structure removal/modification<br>Fish passage measures at Dorena and Cottage Grove<br>Use annual drawdowns at all or most projects, where feasible<br>Pacific lamprey passage be considered at all projects<br>Consider structures at Cougar and Detroit as part of the EIS<br>Include the tribe in water quality discussions<br>Baseline analysis should be pre-system for all resources that existed before the WVS<br><br>Cultural resources are also important to the Grand Ronde:<br>The Grand Ronde have been in consultation with the Corps in the development of the Willamette Valley Project program-level National Historic Preservation Action Section 106 programmatic agreement to manage cultural resources. |

| Federally-Recognized Tribe or Tribal Representative | Issues and Concerns |
|---|---|
| CRITFC, while not a tribe, submitted comments on behalf of representing Yakama, Umatilla, Warm Springs, and Nez Perce tribes | CRITFC provided comments on 6/28/2019 and noted interest and concern with:<br>Tribal fishery of Columbia River and tributaries<br>Non-tribal fishery of Columbia River and tributaries<br>Hatchery production<br>Protection of natural spawning environment<br>Protection of downstream and upstream migration through the river<br>Pacific Lamprey<br>Fish and Wildlife<br>Cumulative Impact Requirement for the Willamette Basin Water Reallocation Project and WVS EIS<br>Water Quality<br>Climate Change<br>Adequate Flows for Fish and Wildlife<br>Tribal Cultural Resources<br>Hydro System Operations<br>Hydro System Structural Modifications<br>Off-site Mitigation<br>Reservoir Ecology<br>Data and Metrics used in EIS Analysis |
| Confederated Tribes of Siletz Indians | The Siletz have been invited to consult with the Corps in the development of the Willamette Valley Project program-level National Historic Preservation Action Section 106 programmatic agreement to manage cultural resources. |
| Cow Creek Band of Umpqua Tribe of Indians | The Cow Creek have been invited to consult with the Corps in the development of the Willamette Valley Project program-level National Historic Preservation Action Section 106 programmatic agreement to manage cultural resources. |

| **Federally-Recognized Tribe or Tribal Representative** | **Issues and Concerns** |
|---|---|
| Confederated Tribes and Bands of the Yakama Nation | A letter from Yakama Tribe stated there are concerns that development for the WVS EIS could interfere with treaty reserved rights in the Yakama tribe's usual and accustomed areas<br>Yakama tribe also requested meaningful technical level engagement with USACE during the NEPA process and the development of the EIS<br>CRITFC also provided comments on behalf of the Columbia River tribes (6/28/2019) |
| Nez Perce Tribe | CRITFC provided comments on behalf of the Columbia River tribes (6/28/2019) |
| Confederated Tribes of the Umatilla Indian Reservation | CRITFC provided comments on behalf of the Columbia River tribes (6/28/2019) |
| Confederated Tribes of Warm Springs | CRITFC provided comments on behalf of the Columbia River tribes (6/28/2019)<br>The Warm Springs tribe has been in consultation with the Corps in the development of the Willamette Valley Project program-level National Historic Preservation Action Section 106 programmatic agreement to manage cultural resources.<br><br>The Warm Springs tribe (CTWS, 2021a) has identified following topics and issues in their usual and accustomed areas:<br>*Fisheries Program*<br>Upland, riparian, and aquatic habitats for fish<br>Natural production of anadromous and resident fish populations<br>Enhancing and supplementing Chinook salmon and steelhead trout populations<br>Providing support and expertise to agencies that manage fisheries programs |

| Federally-Recognized Tribe or Tribal Representative | Issues and Concerns |
|---|---|
| | *Conservation Lands Program and the Willamette Wildlife Mitigation Program (ODFW, n.d.).*<br>Little Sweden is 183.17acres of privately-owned tribal lands on the North Santiam River, directly downstream from Big Cliff Reservoir (1 mile west of the dam). The tribe manages it for members to hunt, fish, gather forest products, and recreate. It is managed to fish and wildlife habitat. This is not an ITA.<br>Austin Hot Springs is a 151.7-acre privately-owned tribal property in the Clackamas River drainage. It is not located on the WVS. This is not an ITA.<br>Red Hills is a privately-owned tribal property of 278.5 acres of fish and wildlife habitat. Tribal members can hunt, fish, gather forest products, and recreate. This is not an ITA. |

Tallying treaty rights and reserved rights, ancestral territories and usual and accustomed areas, and the resources held within to attempt to quantify tribal resources would be difficult (if not impossible), but it is accurate to state that the entirety of the WRB landscape and resources are important to the tribes being consulted as part of this EIS. The WBR as a whole can be considered a tribal resource when taking the views and beliefs of the tribes into consideration.

### 3.24.3 Environmental Consequences

This section briefly summarizes results from the environmental consequences sections for Water Quality (Section 3.5), Fish, Aquatic Invertebrates, and Habitat (Section 3.8), Wildlife, Birds, and Terrestrial Habitat (Section 3.9), and Cultural Resources (Section 3.21). These sections were selected to reflect the primary concerns outlined by the tribes as discussed in the affected environment (3.24.2). Refer to the resource sections in Chapter 3 for full consideration of impacts including climate change.

#### *3.24.3.1 No Action Alternative*

The NAA would represent the current management direction of the WVS. Specific measures included in the NAA are described in Section 2.4.1.

The NAA is predicted to have MAJOR adverse impacts on UWR Chinook salmon and winter steelhead. Life cycle models predict high extinction risk in all sub-basins for both species. Adverse impacts on bull trout are predicted to be MINOR. Bull trout above Cougar have been stable for several years and have been increasing above Hills Creek. Habitat scores for bull trout are reasonable, with one hundred percent of the spawning habitat available, and 70% of the rearing/foraging habitat available. The WVS passage conditions at dams limit bull trout access to below dam rearing/foraging habitat. Climate change is predicted to further degrade habitat for bull trout particularly below dams and will reduce the ability to meet operational fish passage, minimum flows, and water temperature objectives below dams for UWR spring Chinook salmon and UWR steelhead.

No fish passage improvements would be proposed as part of the NAA. This would continue to limit foraging opportunities for piscivorous wildlife species such as river otters, muskrats, and eagles within stream reaches upstream of the WVS dams where passage has not been provided for native migratory fish, including salmonids and Pacific lamprey (Lampetra tridentata). This would result in a long-term, minor, adverse effect to piscivorous wildlife species and overall habitat function in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins.

The No Action Alternative (NAA) maintains existing operations and maintenance activities including a rule curve that begins drafting in fall to low water levels through the winter, with fill beginning in late winter through the spring, with the highest reservoir level to be reached by the start of summer. This level is maintained through early fall when drafting begins again. This annual draft and fill cycle is a major erosion event for archaeological sites that exist in all of the reservoirs except Big Cliff and Dexter (reregulating dams that maintain high reservoir elevations). These resources have been experiencing this cyclical inundation and exposure for five to eight decades depending on the reservoir. Of the 461 archaeological sites documented at the WVS, 369 (80%) are located in or adjacent to reservoir environments. No new construction or modification to the 13 historic districts is proposed under the NAA. The overall effect from the NAA to Cultural Resources would be irreversible, adverse, and major within the WVS.

This alternative does not consider lamprey passage or habitat improvement, and has minor, long-term adverse effects to wildlife and habitat. The NAA would have major adverse impacts to cultural resources and fish. The NAA does not benefit tribal resources.

#### *3.24.3.2 Alternative 1 – Project Storage Alternative*

Alternative 1 proposes to improve fish passage through storage-focused measures. Specific measures included in the Alternative 1 are described in Section 2.4.3.

Compared to the NAA, Alternative 1 would result in minor to major beneficial water temperature effects in the Middle Fork Willamette, South Santiam, and North Santiam basins due to the proposed temperature control structures at Lookout Point, Green Peter, Detroit Dams. Minor to Major beneficial TDG effects are expected in the North Santiam and South Fork

McKenzie basins based on the reduced number of spill days and proposed TDG abatement structures in Alternative 1.

Large floating fish passage structures would be implemented compatible with water storage needs in the North, South Santiam, and the Middle Fork. A fall deep drawdown at Fall Creek will continue. Minimum below-dam flow values support capturing water in reservoirs during spring. Alternative 1 implementation is predicted to have MAJOR impacts on UWR spring Chinook salmon and MINOR adverse impacts on UWR steelhead in the North and South Santiam as compared to the NAA. Lifecycle models predict low extinction risk for Chinook in the North and South Santiam, and high risk of extinction in the McKenzie and Middle Fork. The downstream passage structure at Lookout Point is dependent on the dam operations and predicted to perform poorly likely due to the storage theme of Alternative 1. Both life cycle models predict low extinction risk in Santiam UWR steelhead populations, although one model predicted low recruits per spawning for the South Santiam. Scores and risks for bull trout would be ranked similar to the NAA, with MINOR effects predicted. Habitat scoring for bull trout is only marginally better than in the NAA with rearing/forage habitat increases for North Santiam bull trout below Detroit. Structural improvements for fish passage and water temperature provide resilience to climate change by increasing operational flexibility in the North Santiam, South Santiam, McKenzie and Middle Fork sub-basins.

Alternative 1 will provide lamprey passage at Dexter dam (Measure 52); fish passage at the Long Tom River drop structures downstream of Fern Ridge (Measure 639); and downstream fish passage at Detroit (operation not a structure), Foster, Green Peter, Lookout Point, and Detroit dams (Measure 392). This would improve lamprey populations in the Middle Willamette subbasin and salmonid populations in the North Santiam, South Santiam, Long Tom, and Middle Willamette subbasins as compared to the NAA. Improving fish populations will provide long-term minor benefits in terms of increased foraging opportunities for piscivorous wildlife species. In addition, improving anadromous salmonid populations in the North Santiam, South Santiam, Long Tom, and Middle Willamette subbasins will have minor long-term benefits compared to the NAA for habitat functions related to nutrient cycling as a result of fish decaying in these sub-basins after spawning.

Like the NAA, Alterative 1 follows a rule curve that results in one major cycle of draft and fill per water year. Alternative 1 would reduce minimum flows to Congressionally authorized minimum flow requirements (#723) at all of the reservoirs except Dexter, Foster, and Big Cliff. This measure would likely have minor short-term benefits to archaeological resources on a system wide level since it would allow for more water storage and a higher likelihood of following the rule curve in a consistent pattern as compared to the NAA. This is supported by the systemwide 3% decrease in acre-days of site exposure between the NAA (164,109 acre-days) and Alternative 1 (158,734 acre-days). Alternative 1 is the only alternative that includes Measure 723, and it is the only Alternative that shows minor beneficial changes at the system-level to cultural resources. As with the NAA, the WVS cycle of draft and fill will continue to adversely affect 369 (80%) of the archaeological sites present. Alternative 1 has the potential to cause moderate to major effects to six of the 13 historic districts with proposed structural measures that support water quality, downstream and upstream fish passage. The overall effect from Alternative 1 to Cultural Resources would be irreversible, adverse, and major within the WVS when compared to the NAA.

Alternative 1 includes lamprey passage measures and there are some reduced adverse impacts to UWR spring Chinook salmon and UWR steelhead, though increased adverse impacts to Bull Trout as compared to the NAA. Water quality with regard to temperature and TDG measures in Alternative 1, have moderate to major beneficial effects for ESA-listed species. Alternative 1 has major adverse impacts to cultural resources, though slightly improved when compared with the NAA through reduced days of site exposure. This alternative benefits some tribal resources and reduces adverse effects to other tribal resources when compared to the NAA.

#### *3.24.3.3 Alternative 2A – hybrid alternative*

Alternative 2A includes structural and operational measures to provide flexible water management. It also includes a structural downstream passage measure at Cougar Dam. Specific measures included in the Alternative 2A are described in Section 2.4.4.

Compared to NAA, Alternative 2A resulted in minor to major beneficial water temperature effects in the North and South Santiam sub-basins due to the proposed temperature control structure at Detroit dam and the Green Peter fall deep drawdown. Minor to moderate beneficial TDG effects are expected in the North Santiam due to the proposed temperature control structure at Detroit that removes the need for operational temperature control with non-turbine outlets. Moderate to major adverse TDG effects are expected in the South Santiam due to the Green Peter fall deep drawdown that relies on more spill flow in in Alternative 2A when compared to the NAA.

This alternative includes structural downstream passage at Detroit, Foster, Cougar and Lookout Point dams, and operational passage at Green Peter Dam. A fall deep reservoir drawdown at Fall Creek Dam will continue. Alternative 2A would have MODERATE adverse effects on UWR spring Chinook salmon and is predicted to produce the most viable populations compared to any other alternative while retains the McKenzie core legacy population. For the South Santiam the LCM does not predict a viable population above Foster. Alternative 2A produces the most optimistic outcomes for UWR spring Chinook salmon in the Middle Fork among all the alternatives.

Alternative 2A would have MINOR adverse impacts to Santiam UWR steelhead populations when compared to the NAA, with good performance in all metric dimensions in both life cycle models except for the South Santiam under the LCM. EDT results shows resiliency with respect to recruits per spawner. Bull trout habitat scores and risks are comparable to Alternative 1, with a fish passage addition providing access to habitat below Cougar Dam. Alternative 2A would have MINOR adverse impacts for bull trout compared to the NAA. Structural improvements for fish passage and water temperature provide resilience to climate change by increasing operational flexibility in the North Santiam, South Santiam, and Middle Fork sub-basins.

Alternative 2A would include adding a WTC tower at Detroit (Measure 105); lamprey passage at Green Peter (Measure 52); and downstream passage structures (Measure 392) at Detroit, Foster, Cougar, and Lookout Point. Measures included are focused on improving water quality and fish passage. This should improve lamprey populations in the South Santiam subbasin and salmonid populations in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins compared to the NAA. Improving fish populations will provide long-term minor beneficial effects in terms of increased foraging opportunities for piscivorous wildlife species including, but not limited to, river otters, snakes, racoons, weasels, eagles, osprey, great blue herons, etc.

Like the NAA and Alterative 1, Alternative 2A follows a rule curve that results in one major cycle of draft and fill per water year. This cycle impacts 369 (80%) of known archaeological sites. Alternative 2A proposes a deeper fall reservoir drawdown at Green Peter and Fall Creek as opposed to just Fall Creek (with the NAA and Alternative 1). A deep fall drawdown would increase erosion at Green Peter and Fall Creek reservoirs, but the adverse effect to documented archaeological sites is not fully measurable. The number of reservoirs impacted on a project-level doubles in this Alternative and results in a higher number of documented archaeological sites that would be subject to this increased erosion as compared to the NAA.

Alternative 2A includes lamprey passage measures, has moderate to major water quality benefits (with the exception of moderate to major adverse effects to TDG expected at Green Peter), has minor benefits to piscivorous species, and there are minor to moderate adverse effects to UWR spring Chinook salmon and UWR steelhead as compared to the NAA. This alternative predicts the most positive outcomes for population survival of any alternative. Alternative 1 and 2A have similar adverse impacts to Bull Trout. This alternative is more beneficial to fisheries resources when compared to the NAA and Alternative 1. However, Alternative 2A has major adverse impacts to tribal resources, increased from the NAA and Alternative 1.

##### *3.24.3.3.1 Near-term operations Measures*

Throughout Chapter 3, each resources section considers the impacts of the near-term operations measure. Please refer to these sections. Overall, the operations are in place to improve anadromous fish passage, which is a positive effect to fisheries tribal resources. Adverse effects to wildlife and other fish are anticipated to be minor. Most of the operations in the measure have irreversible adverse impacts to cultural resources as compared to the NAA. These impacts are the same under every alternative as they were analyzed for the full temporal scope of the PEIS.

#### *3.24.3.4 Alternative 2B -- Hybrid Alternative*

The primary difference between Alternatives 2A and 2B is at Cougar dam, the diversion tunnel will be used for fish passage for Alternative 2B whereas for Alternative 2A, an FSS will be used. Specific measures included in Alternative 2B are described in Section 2.4.5.

Compared to NAA, Alternative 2B resulted in minor to major beneficial water temperature effects in the North Santiam, South Santiam, and South Fork McKenzie sub-basins due to the proposed temperature control structure at Detroit dam, Green Peter fall deep drawdown with operational temperature control, and a deep drawdown at Cougar. Minor to moderate beneficial TDG effects are expected in the North Santiam and South Fork McKenzie sub-basins due to a reduced number of days with spill (at Detroit, the proposed temperature control structure removed the need for operational temperature control with non-turbine outlets). Minor beneficial TDG effects are expected in the South Fork McKenzie sub-basin under Alternative 2B due to the deep drawdown at Cougar that involves use of the diversion tunnel, which is expected to have lower TDG than the regulating outlet. Moderate to major adverse TDG effects are expected in the South Santiam due to the Green Peter autumn deep drawdown that relies on more spill flow in Alternative 2A than the NAA.

The only difference between Alternative 2A and Alternative 2B is that 2B has an operational downstream fish passage measure at Cougar Dam (deep drawdown to near the diversion tunnel in spring and fall) instead of a structural measure. Cougar Reservoir would largely be drained in spring and only partially refilled in summer due to summer inflow, resulting in most juvenile Chinook moving downstream of Cougar Dam and a significant reduction in rearing/foraging opportunity within the reservoir for bull trout. Many bull trout would be expected to move upstream into the South Fork McKenzie, or below Cougar Dam during spring and fall reservoir drawdowns. Suitable habitat for bull trout exists above and below Cougar Dam and Reservoir, however carry capacity and other effects of redistribution on survival and spawning is uncertain. The deep draft in spring will also eliminate conservation water storage, resulting in lower summer stream flows and changes in water temperatures below Cougar Dam. These differences will affect fish rearing/foraging patterns both above and below Cougar Dam as compared to the NAA. Compared to Alternative 2A, 2B results in increased adverse impacts to UWR spring Chinook salmon (moderate) and bull trout (moderate) in the McKenzie, otherwise impacts are predicted to be the same as for Alternative 2A. Structural improvements for fish passage and water temperature provide resilience to climate change by increasing operational flexibility in the North Santiam, South Santiam, and Middle Fork sub-basins.

Alternative 2B would include adding a WTC tower at Detroit (Measure 105); lamprey passage at Green Peter (Measure 52); and downstream passage structures (Measure 392) at Detroit, Foster, and Lookout Point. As previously mentioned, downstream passage at Cougar is provided through the spring and fall drawdowns to the diversion tunnel (Measures 40 and 720). Measures included are focused on improving water quality and fish passage. This should improve lamprey populations in the South Santiam subbasin and salmonid populations in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins. Improving fish populations will provide long-term minor beneficial effects in terms of increased foraging opportunities for piscivorous wildlife species including, but not limited to, river otters, snakes, racoons, weasels, eagles, osprey, great blue herons, etc. when compared to the NAA.

Alterative 2B as well as the NAA, Alternative 1, and Alternative 2A follows a rule curve that results in one major cycle of draft and fill per water year. Alternative 2B proposes a deep spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40) at Cougar (1330 feet) and fall deep drawdown at Green Peter and Fall Creek. Overall, the WVS would see a 4% system-wide increase in site exposure with Alternative 2B as compared to the NAA. Alternative 2B has the potential to cause moderate to major effects to six of the 13 historic districts with proposed measures that support water quality, downstream and upstream fish passage. The overall effect from Alternative 2B to cultural resources would be irreversible, adverse, and major within the WVS when compared to the NAA.

Alternative 2B includes lamprey passage measures at multiple projects and would result in minor to major water quality improvements (except TDG levels at Green Peter) when compared to the NAA. There are reduced adverse impacts to UWR spring Chinook salmon and UWR steelhead when compared to the NAA and Alternative 1, and similar but slightly increased adverse effects when compared to Alternative 2A. Alternative 1 and 2A have similar adverse impacts to Bull Trout. This alternative has less adverse effects to fisheries resources when compared to the NAA and Alternative 1, but slightly more adverse effects that Alternative 2A. Alternative 2B has major adverse impacts to tribal resources compared to the NAA.

##### *3.4.3.4.1 Near-Term Operations Measures*

See Section 3.24.3.3.1.

#### ***3.24.3.5 Alternative 3A – Operations-Focused Fish Passage Alternative***

Alternative 3A proposes to improve fish passage through operations-focused measures including downstream passage at Cougar through deep drawdown to lowest regulating outlets. Specific measures included in the Alternative 3A are described in Section 2.4.6.

Compared to NAA, Alternative 3A resulted in minor to major beneficial water temperature effects in the Middle Fork Willamette (between Hills Creek dam and Lookout Point Dam) and South Santiam sub-basins due to the proposed deep drawdowns at Hills Creek and Green Peter dams. In the North Santiam sub-basin, minor beneficial effects to water temperature are expected during the autumn while moderate adverse effects are expected during the spring-summer due to deep drawdown at Detroit Dam in Alternative 3A. In the South Fork McKenzie sub-basin, minor adverse effects to water temperature are expected during the fall due to a partial drawdown at Cougar Dam in Alternative 3A. Minor to major adverse TDG effects are expected in the North Santiam, South Santiam, and Middle Fork Willamette as compared to the NAA due to the deep drawdowns at Detroit, Green Peter (autumn) and Lookout Point that rely on higher outflows and/or spill flow in Alternative 3A.

Reservoir drawdowns will occur in spring and fall at Detroit, Cougar (to RO), and Lookout dams. Spring surface spill and fall deep drawdowns will occur at Green Peter and Hills Creek. The fall deep drawdown at Fall Creek from the NAA will continue. Alternative 3A would have Major adverse impacts for UWR spring Chinook salmon and UWR steelhead when compared to the NAA. Predicted performance for these species is very similar to the NAA, with some improvement in North Santiam UWR spring Chinook salmon and South Santiam UWR steelhead. Alternative 3A would have Major adverse impacts for Bull trout compared to the NAA. Reservoir rearing/foraging area is significantly reduced in both Detroit and Cougar reservoirs and expected to result in increased movement into more degraded rearing/foraging habitat below Detroit and Hills Creek dams where spawning habitat does not exist and human disturbance is high. Climate change is predicted to further degrade habitat for bull trout below dams and will reduce the ability to meet operational fish passage, minimum flows, and water temperature targets below dams for UWR spring Chinook salmon and UWR steelhead.

Alternative 3A will also provide lamprey passage at Blue River, Green Peter, and Hills Creek dams; downstream spillway fish passage at Big Cliff, Dexter, Fall Creek, Green Peter, and Hills Creek dams. This should improve lamprey populations in the McKenzie, South Santiam, and Middle Fork Willamette subbasins and salmonid populations in the North Santiam, South Santiam, and Middle Fork Willamette subbasins. Improving fish populations will provide long-term minor beneficial effects in terms of increased foraging opportunities for piscivorous wildlife species including, but not limited to, river otters, snakes, raccoons, weasels, eagles, osprey, great blue herons, etc. that use habitat upstream of the dams in these subbasins when compared to the NAA.

Alterative 3A deviates strongly from the NAA as well as Alternative 1, Alternative 2A, and Alternative 2B in regard to the increase in potential impacts to archaeological resources. Fall deep drawdowns are proposed for six reservoirs including Blue River, Hills Creek, Green Peter, Detroit, Lookout Point, and Cougar beyond the annual cycle of draw and fill. Spring deep drawdowns are proposed at three of those reservoirs including Detroit, Lookout Point, and Cougar. At all of these reservoirs accelerated erosion will impact slope stability and the archaeological sites present, but at much larger scale than the NAA. Nearly 50% of reservoirs and present sites will be vulnerable to increased erosion from the fall deep drawdowns, and nearly 25% of reservoirs will experience additional erosion by doubling the cycle of draft and fill that occur in one water year. The WVS would experience a 44% increase in site exposure from the NAA. Adverse effects specifically to archaeological sites at seven reservoirs would be substantially high.

Alternative 3A would also greatly lengthen the amount of time that sites at Detroit, Lookout Point, and Cougar Reservoir will be exposed to human-induced impacts. Alternative 3A has the potential to cause moderate to major effects to four of the 13 historic districts with proposed measures that support water quality, downstream and upstream fish passage. The overall effect from Alternative 3A to Cultural Resources would be irreversible, adverse, and major within the WVS as compared to the NAA.

Alternative 3A has major adverse impacts to cultural resources, which greatly increase compared to the NAA, Alternative 1, Alternative 2A, and Alternative 2B. The alternative does include lamprey passage measures at multiple projects, but moderate to major adverse effects are increased for UWR spring Chinook salmon, UWR steelhead and Bull Trout. While there are some benefits to water quality, overall this alternative has the most adverse effects to water quality compared to the NAA, Alternative 1, 2A, and 2B. This alternative has the most adverse effects to tribal resources.

##### *3.24.3.5.1 Near-Term Operations Measures*

See Section 3.24.3.3.1.

#### ***3.24.3.6 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at COU)***

Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)

Alternative 3B is similar to Alternative 3A in that it proposes to improve fish passage through operations-focused measures, but it includes downstream passage at Cougar through the diversion tunnel. Specific measures included in the Alternative 3B are described in Section 2.4.7.

Compared to NAA, Alternative 3B resulted in minor to moderate beneficial water temperature effects in the Middle Fork Willamette, McKenzie, and South Santiam sub-basins due to the proposed drawdowns at Hills Creek, Lookout Point, Cougar, and Green Peter dams. Minor to major adverse TDG effects are expected in the North Santiam, South Santiam, and Middle Fork Willamette (below Dexter Dam) as compared to the NAA, due to the deep drawdowns at Detroit (autumn), Green Peter, and Lookout Point (autumn) that rely on high outflows, thereby increasing the number of days with spill in Alternative 3B. Minor beneficial TDG effects are expected in the South Fork McKenzie sub-basin under Alternative 3B due to the deep drawdown at Cougar that involves use of the diversion tunnel, which is expected to have lower TDG than the regulating outlet when compared to the NAA.

Reservoir drawdowns will occur in spring and fall at Green Peter (to RO), Cougar (to DT), and Hills Creek dams (to RO). Spring surface spill and fall drawdowns (to RO) will occur at Detroit and Lookout Point dams. A fall deep drawdown at Fall Creek will continue as under the NAA. Alternative 3B would have Moderate to Major adverse impacts for UWR spring Chinook salmon and UWR steelhead. Performance for Chinook in the North Santiam and McKenzie is predicted as viable to nearly viable, and the same for steelhead in the North and South Santiam. Alternative 3B would have Moderate to Major adverse impacts for bull trout. Reservoir rearing/foraging area is reduced in Cougar Reservoir, and passage will result in increased movement into more degraded rearing/foraging habitat below Detroit and Hills Creek dams where spawning habitat does not exist and human disturbance is high. Climate change is predicted to further degrade habitat for bull trout below dams and will reduce the ability to meet operational fish passage, minimum flows, and water temperature targets below dams for UWR spring Chinook salmon and UWR steelhead.

There are also differences in terms of fish passage improvements between 3A and 3B. Alternative 3B will improve fish passage by providing downstream passage through the spillways at Big Cliff, Detroit, Dexter, and Lookout Point dams as well as through the drawdowns previously discussed. Lamprey passage will be provided at Hills Creek, Blue River, and Green Peter. Improving lamprey and salmonid populations in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins will provide long-term minor beneficial effects in terms of increased foraging opportunities for piscivorous wildlife species including but not limited to river otters, snakes, raccoons, weasels, eagles, osprey, great blue herons, etc. upstream of the dams in these subbasins compared to the NAA.

Alterative 3B shares similarities with 3A, but is quite different from the NAA, Alternative 1, Alternative 2A, and Alternative 2B. Deeper fall reservoir drawdowns (#40) are proposed for the same seven reservoirs including Fall Creek, Blue River (1165 feet), Hills Creek (1446 feet), Green Peter (780 feet), Detroit (1375 feet), Lookout Point (761 feet), and Cougar (1517 feet). Spring reservoir drawdowns (#720), however, are proposed at Hills Creek, Cougar, and Green Peter. In both of these alternatives, Cougar would have a spring and fall deep drawdown. In Alternative 3B, the fall deep drawdown at Cougar would pass through the diversion tunnel. The WVS would experience a 31% higher site exposure rate than the NAA.

Adverse effects specifically to archaeological sites at seven of the reservoirs are substantially high. Like with Alternative 3A, accelerated erosion would impact slope stability and the archaeological sites present in the reservoirs, at a similar scale, but with slightly different locations. Again, more than 50% of reservoirs and associated archaeological sites would be vulnerable to increased erosion from the fall deep drawdowns, and nearly 25% of reservoirs would experience additional erosion by doubling the cycle of draft and fill that occur in one water year compared to the NAA. Alternative 3A has the potential to cause moderate to major effects to four of the 13 historic districts with proposed measures that support water quality, downstream and upstream fish passage. The overall effect from Alternative 3B to Cultural Resources would be irreversible, adverse, and major within the WVS.

Like Alternative 3A, Alternative 3B has major adverse impacts to cultural resources compaired the NAA, Alternative 1, Alternative 2A, and Alternative 2B. The alternative does include lamprey passage measures at multiple projects, but moderate to major adverse effects would occur for UWR spring Chinook salmon, UWR steelhead, and Bull Trout. Overall this alternative has adverse effects to water quality similar to those of 3A (and more adverse than the NAA, Alternative 1, Alternative 2A, and Alternative 2B), but it is improved from Alternative 3A due to the lower TDG anticipated through the use of the Cougar diversion tunnel. This alternative has a similar level of adverse effects as Alternative 3A to tribal resources.

##### *3.24.3.6.1 Near-Term Operations Measures*

See Section 3.24.3.3.1.

#### ***3.24.3.7 Alternative 4 – Structures-Based Fish Passage Alternative***

Alternative 4 proposes to improve fish passage through a structure-based approach. Specific measures included in the Alternative 4 are described in Section 2.4.8.

Compared to NAA, Alternative 4 resulted in minor to major beneficial water temperature effects in the Middle Fork Willamette (between Hills Creek Dam and Lookout Point Dam), South Santiam, and North Santiam basins due to the proposed temperature control structures at Hills Creek, Lookout Point, and Detroit Dams as well as operational temperature control at Green Peter Dam. Minor to Major beneficial TDG effects are expected in the North Santiam and South Fork McKenzie sub-basins based on the proposed TDG abatement structures below Detroit and Big Cliff Dams and the reduced number of spill days at Cougar Dam in Alternative 4.

Alternative 4 is a structural focused alternative and includes large floating fish passage structures coupled to temperature structures in the North, McKenzie, and the Middle Fork. Smaller structures are included at Foster Dam in the South Santiam. A fall deep drawdown at Fall Creek will continue. Alternative 4 adverse effects are predicted to be Moderate for UWR spring Chinook salmon and MINOR for UWR steelhead compared to the NAA. Life cycle models predict low extinction risk for UWR spring Chinook salmon for the North and South Santiam, and for the McKenzie. Only one model predicts low extinction risk for Middle Fork Chinook. Life cycle models predict low extinction risk for North Santiam UWR steelhead, but only one model predicts low extinction risk for South Santiam steelhead. The EDT output also indicates Alternative 4 is somewhat resilient to different hydrology year types with respect to life history diversity.

Alternative 4 is predicted to have Moderate adverse impacts for bull trout. Habitat scoring for bull trout is improved in all three sub-basins due to passage actions, however access to below dam habitat increases demographic risks especially below Hills Creek and secondarily below Detroit where spawning habitat does not exist, and human disturbance is high. Climate change is predicted to further degrade habitat for bull trout below dams. Structures for fish passage and temperatures will increase resiliency to climate change by improving operational flexibility.

This alternative would include adding WTC towers (Measure 105) at Detroit, Hills Creek, and Lookout Point; lamprey passage (Measure 52) at Hills Creek; up and downstream passage at Fern Ridge (Measure 639); and downstream passage structures (Measure 392) at Cougar, Detroit, Foster, Hills Creek, and Lookout Point (fish collection around Dexter). Measures included are focused on improving water quality and fish passage. This would improve lamprey populations in the Middle Willamette subbasin and salmonid populations in the North Santiam, South Santiam, Long Tom, and Middle Willamette Fork subbasins. Improving fish populations will provide long-term minor beneficial effects in terms of increased foraging opportunities for piscivorous wildlife species including, but not limited to, river otters, snakes, raccoons, weasels, eagles, osprey, great blue herons, etc. upstream of the dams in these subbasins compared to the NAA.

Alterative 4 follows a rule curve that results in one major cycle of draft and fill per water year and is similar to Alternative 1 in regard to impacts to archaeological resources. The impacts are also similar to the NAA. Alternatives 4, however, does not propose any deep drawdowns or spring spills over the spillway. Rather this alternative focuses heavily on structure-based measures to accomplish downstream fish passage. Like Alternative 1, Alternative 4 would result in a minor increase in system-wide site exposure (3% increase from NAA). As with the NAA, the WVS cycle of draft and fill will continue to adversely affect 369 (80%) of the archaeological sites present. Alternative 4 has the potential to cause moderate to major effects to seven of the 13 historic districts through measures that support water quality, downstream and upstream fish passage. The overall effect from Alternative 4 to Cultural Resources would be irreversible, adverse, and major within the WVS.

The alternative provides minor benefits to piscivorous species and does include some lamprey passage, but at limited projects compared to the NAA. Water quality has minor to major improvements on par with Alternative 1 though improved from the NAA and Alternatives 2A, 2B, 3A, and 3B. Overall the impacts to UWR spring Chinook salmon, UWR steelhead, and Bull Trout are similar to those for Alternatives 2A and 2B and improved from the NAA and Alternatives 1, 3A, and 2B. Alternative 4 and the NAA have similar adverse effects to archaeological sites, improved from Alternatives 2A, 2B, and greatly improved from Alternatives 3A and 3B. Alternative 4 has the greatest adverse impacts to the built environment resources and slightly more than Alternatives 1, 2A, and 2B. Alternative 4 has a range of beneficial to adverse effects to tribal resources compared to the NAA.

##### *3.24.3.7.1 Near-term operations measures*

See Section 3.24.3.3.1.

#### ***3.24.3.8 Alternative 5 – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)***

Alternative 5 is nearly identical to Alternative 2B except that the integrated temperature and habitat flow regime (Measure 30a) has been replaced by the refined integrated temperature and habitat flow regime (Measure 30b). Specific measures included in the Alternative 5 are described in Section 2.4.9.

Compared to NAA, Alternative 5 would likely result in minor to major beneficial water temperature effects in the North Santiam, South Santiam, and South Fork McKenzie sub-basins due to the proposed temperature control structure at Detroit dam, Green Peter deep autumn drawdown with operational temperature control, and a deep drawdown at Cougar. Minor to moderate beneficial TDG effects are expected in the North Santiam and South Fork McKenzie sub-basins due to a reduced number of days with spill (at Detroit, the proposed temperature control structure removed the need for operational temperature control with non-turbine outlets). Minor beneficial TDG effects are expected in the South Fork McKenzie sub-basin under Alternative 5 due to the deep drawdown at Cougar that involves use of the diversion tunnel, which is expected to have lower TDG than the regulating outlet. Moderate adverse TDG effects are expected below Green Peter Dam (above Foster Lake) due to the Green Peter autumn deep drawdown that relies on more spill flow in Alternative 5 compared to the NAA.

Despite the change in minimum flows, little to no difference between 2B and 5 is predicted regarding reservoir volumes or flows below dams, since reservoir drafting during the conservation use season and early flood seasons result in stream flows remaining above minimums. Therefore, the same impacts to Chinook, steelhead and bull trout are predicted from Alternative 5 as for Alternative 2B. Structural improvements for fish passage and water temperature provide resilience to climate change by increasing operational flexibility in the North Santiam, South Santiam, McKenzie and Middle Fork sub-basins.

Alternative 5 would include adding a WTC tower at Detroit (Measure 105); lamprey passage at Green Peter (Measure 52); and downstream passage structures (Measure 392) at Detroit, Foster, and Lookout Point. As previously mentioned, downstream passage at Cougar is provided through the spring and fall drawdowns to the diversion tunnel (Measures 40 and 720). Measures included are focused on improving water quality and fish passage. This should improve lamprey populations in the South Santiam subbasin and salmonid populations in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins. Improving fish populations will provide long-term minor beneficial effects in terms of increased foraging opportunities for piscivorous wildlife species including, but not limited to, river otters, snakes, racoons, weasels, eagles, osprey, great blue herons, etc. compared to the NAA.

Alterative 5 follows a rule curve that results in one major cycle of draft and fill per water year. Alternative 5 proposes a deep spring reservoir drawdown (#720) and deeper fall reservoir drawdowns (#40) at Cougar (1330 feet) and fall deep drawdown at Green Peter and Fall Creek. Overall, the WVS would see a 4% system-wide increase in site exposure with Alternative 5 compared to the NAA. Alternative 5 has the potential to cause moderate to major effects to six of the 13 historic districts with proposed measures that support water quality, downstream and upstream fish passage. The overall effect from Alternative 5 to Cultural Resources would be irreversible, adverse, and major within the WVS.

Alternative 5 effects are on par with Alternative 2B. Alternative 5 includes lamprey passage measures at multiple projects and would result in minor to major water quality improvements (except moderate adverse impacts to Green Peter TDG levels) that are similar to Alternatives 2A and 2B compared to the NAA that has none. Water quality would be improved compared to Alternatives 3A and 3B but have more adverse effects than Alternative 4. There are reduced adverse impacts to UWR spring Chinook salmon and UWR steelhead when compared to the NAA and Alternatives 1, 3A, and 3B, but increased adverse effects when compared to Alternative 2A and 4. Alternative 1, 2A, 2B, and 4 have similar adverse impacts to Bull Trout. This alternative has less adverse effects to fisheries resources when compared to the NAA and Alternatives 1, 3A, 3B, and 4, but slightly more adverse effects that Alternative 2A. Alternative 5 has major adverse impacts to cultural resources, increased from the NAA, Alternative 1, and Alternative 2A, but reduced from Alternatives 3A and 3B.

#### *3.24.3.8.1 Near-term operations measures*

See Section 3.24.3.3.1.

## 3.25 UNAVOIDABLE ADVERSE EFFECTS

Unavoidable adverse effects are those effects that cannot be avoided or fully mitigated should the alternatives be implemented. The effects of the Alternatives are described in Chapter 3 and some of them may not be fully avoided, as identified in CEQ regulations (40 C.F.R. § 1502.16). Location and intensity of unavoidable effects would vary by alternative. Physical laws and processes make erosion and sedimentation unavoidable. If storage reservoirs are operated according to their intended function, with drafting and refilling cycles, the reservoir elevations may fluctuate substantially, reservoir shorelines would be exposed, and islands could be bridged. Unavoidable effects from storage reservoir operations include blowing dust from exposed sediments, diminished visual quality, damage to archaeological sites, and some degree of disruption to resident fish spawning and food availability. Seasonal limitations on use of recreation facilities could be avoided by modifying the facilities, but it would be impractical to eliminate all elevation-based recreation effects. Several types of effects are unavoidable with the current configuration of the system, such as some degree of disruption to anadromous and resident fish spawning and food availability. Projected effects at the WVS projects would result from operational changes that disrupt established uses dependent upon certain elevation patterns. If operations change those elevation patterns, some degree of effect to the established uses is unavoidable.

## 3.26 RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

This analysis looks at the relationship between short-term uses of environmental resources and the maintenance and enhancement of long-term productivity. WVS operations may cause both short-term and long-term effects to the affected environment that cannot be mitigated. All of the alternatives would cause some mix of short-term effects, including soil erosion, dust generation, degradation of water quality, loss of riparian or wetland vegetation, disruption of fish and wildlife habitat, disruption of recreational use, degradation of visual quality, and effects to cultural resources. In general, the extent these would be long-term effects would depend upon how long a given operation was continued. Some of the short-term changes could soon lead to long-term decreases in productivity. For example, dam releases that contribute to downstream flow levels going below those required for irrigation pumps could result in long-term agricultural productivity losses, if irrigators do not modify their pumps. The short-term and long-term uses of the environment for WVS operations could have some beneficial effects on long-term productivity. The continued availability of power should help maintain the region's reliability. Operations intended to benefit anadromous and resident fish should contribute to the survival and recovery of ESA-listed species and to the maintenance of other stocks. Some of the alternatives would improve conditions for anadromous and resident fish and wildlife, and this could improve the long-term productivity of these resources.

## 3.27 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Irreversible and irretrievable commitments generally affect environmental resources such as soils, wetlands, and riparian areas, but can involve financial resources. Such commitments are considered irreversible and irretrievable because their implementation would affect a resource that has deteriorated to the point that renewal can occur only over a long period or at a great expense, or because they would cause the resource to be destroyed or removed. Few of the operational effects resulting from operation of existing facilities would be irreversible or irretrievable. Loss of soil due to erosion is an irreversible and irretrievable commitment. The construction of new facilities would result in irreversible and irretrievable commitments of upland and blow ordinary highwater areas as well as financial resources. As this is a PEIS and the detailed locations and designs for these structures have been developed, the irreversible and irretrievable commitment of resources will not be known until future tiered NEPA is performed, as discussed in Chapter 7.

Because all of the alternatives, including current operations, involve reservoir fluctuation at some of the projects, erosion would occur at these projects under all of the alternatives. The abundance and quality of wetland and riparian habitat depend on water levels and timing. The desiccation of wetland plants due to drafting at storage reservoirs in some cases would be an irreversible commitment. The desiccation of submerged aquatic plants and mud-dwelling fauna and gradual loss of emergent marsh and riparian vegetation is also an irreversible and irretrievable commitment. These resources could conceivably be restored with higher water levels, but the existing resources would be lost.

Loss of cultural resources resulting from accidental damage or vandalism would be an irreversible and irretrievable commitment. All of the alternatives, including current operations, would expose substantial percentages of known archaeological sites to such damage or vandalism.

## 3.28 INTENTIONAL DESTRUCTIVE ACTS

Intentional destructive acts are acts of vandalism, theft, burglary, sabotage, and terrorism that can disrupt or destroy infrastructure or threaten human health and safety. The area of analysis for intentional destructive acts is the WRB. Although the Bonneville Power Administration (BPA) services areas outside of the WRB, those areas are outside of the scope of this EIS and should not be affected by intentional destructive acts in the area of analysis due to the redundancies[59] and resilience[60] built into the power transmission system.

### 3.28.1 Background

BPA is a division of the U.S. Department of Energy (DOE) and is a cooperating agency for this Draft EIS. Explicit inclusion of intentional destructive acts in NEPA analysis is required for both nuclear and non-nuclear actions proposed by DOE (United States Court of Appeals, 2006).

[59] Redundance is provided by the inclusion of additional critical components in the power grid system in case primary components fail.

[60] Resilience is the ability of a system to withstand disasters (low-frequency, high-impact incidents). For example, if a region's hydropower electricity were to be temporarily shut off, power to the region would still be provided by other sources such as fossil fuels, wind, and nuclear energy.

### 3.28.2 Types of Intentional Destructive Acts

Intentional destructive acts considered in this section include vandalism, theft, burglary, sabotage, and terrorism. While relatively infrequent, these acts have either occurred in the area of analysis in the past or are reasonably foreseeable. Intentional destructive acts generally result in adverse financial effects. Damage to the natural environment can also occur but is less likely.

#### *3.28.2.1 Vandalism, Theft, and Burglary*

Vandalism is the deliberate destruction of property. Theft involves the non-consensual taking of property, whereas burglary involves entering a building with the intent to commit a crime inside. Burglary is often committed with the intent of theft (Mince-Didier, 2022).

According to data collected between 2016 and 2018, the intentional destructive acts that occur most frequently at USACE-managed facilities within the WRB are vandalism, theft, and burglary (Table 3.32-2). The most common intentional destructive act was vandalism, which made up over half of all total reported incidents.

**Table 3.28-1. Intentional Destructive Acts Reported to USACE Within the WRB (2016-2018)**

| Incident Type | Number of Incidents | Percent of Total Incidents[1] |
|---|---|---|
| Vandalism | 102 | 53% |
| Theft | 10 | 5% |
| Burglary | 1 | <1% |
| **Total** | 108 | 56% |

[1]Other incidents recorded by USACE that are not considered intentional destructive acts include but are not limited to vehicle collisions, illegal dumping, and wildfires.

Source: USACE, 2018

According to data collected by BPA, approximately 128 incidents of vandalism, theft, and burglary occurred at BPA-managed facilities between 2007 and 2009. Theft of valuable materials such as metal was the most common crime documented. To deter criminal activity such as unauthorized access to facilities, BPA utilizes physical measures including security fencing and cameras. BPA is currently in the process of replacing solid copper wire with copper-clad steel wire at electrical substations, which is much less expensive and more difficult to cut, in order to prevent future thefts (KGW, 2011). The Bonneville Security and Emergency Response Office works closely with federal law enforcement agencies as well as local and state police to ensure that all incidents are appropriately reported, investigated, and prosecuted. Through its Crime Witness Program, BPA offers up to $25,000 for confidential information that leads to the arrest and conviction of individuals committing crimes against Bonneville facilities. This program has resulted in the return of BPA property and in court-ordered restitutions paid by convicted parties (BPA, 2014).

#### *3.28.2.2 Terrorism and Sabotage*

Terrorism and sabotage are defined similarly and are both carried out in pursuit of political objectives: terrorism is the use of violence and intimidation, while sabotage is the deliberate damage of equipment or structures. Since September 11$^{th}$, 2001, terrorism has been recognized as one of the biggest problems facing the United States. Terrorism and sabotage are more significant threats than vandalism, theft, or burglary because, while far less common, their effects are greater in magnitude and extent. Terrorism and sabotage have not occurred at USACE-managed facilities within the WRB but have occurred at BPA-managed facilities throughout BPA's service area. These acts have generally targeted electrical transmission structures and facilities. In Bend, Oregon in 1999, a large steel transmission tower was toppled, and in Eugene, Oregon in 2011, over $1 million in damages was incurred after substation equipment was damaged in an attempt to disrupt electrical service. BPA maintains close liaisons with federal law enforcement agencies, the Department of Homeland Security, and local jurisdictions to ensure effective communication of information and intelligence to prevent such acts.

# CHAPTER 4 - CUMULATIVE EFFECTS

Council on Environmental Quality (CEQ) regulations for implementing the National Environmental Policy Act (NEPA) require an assessment of cumulative effects. CEQ defines a cumulative effect as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions" (40 CFR § 1508.7). This chapter describes the methods for identification of cumulative actions and presents the results of the cumulative effects analysis.

Cumulative effects may be additive or interactive. Additive effects are the sum of the effects on a resource; for example, groundwater pumping for agricultural irrigation, domestic consumption, and industrial cooling and process activities all contribute incrementally and additively to groundwater aquifer drawdown. Interactive effects may be either countervailing – where the net adverse cumulative effect is less than the sum of the individual effects – or synergistic – where the net adverse cumulative effect is greater than the sum of the individual effects. An example of a countervailing effect is when particulate matter and aerosol air pollutants, which tend to block or reflect sunlight or incoming solar radiation and thus cool the planet surface, counteract the warming effect of carbon dioxide emitted at the same time. A synergistic effect can be demonstrated by the discharge of nutrients and heated water (from use in cooling at thermal power plants) to a river that combine to cause a harmful algal bloom (HAB) and subsequent loss of dissolved oxygen (DO); the combined effects of the HAB and loss of DO are greater than the individual effects added together.

CEQ recommends that cumulative effects analysis be narrowed as much as possible to focus on important issues at a national, regional, or local level (CEQ 1997). The first step in cumulative impact analysis is to identify past, present, and reasonably foreseeable future cumulative actions. The second step is to analyze how, if at all, the effects of the Proposed Action and alternatives may contribute to the effects of the cumulative actions thereby resulting in cumulative effects.

## 4.1 ANALYSIS APPROACH

Methods for cumulative effects analysis are based on the policy guidance and methodology originally developed by CEQ (1997). This method involves identifying affected resources and the associated direct/indirect effects, establishing the geographic and temporal boundaries of the analysis, identifying applicable cumulative actions, and analyzing the cumulative effects of all actions considered.

The effects of all past actions on resources are summarized below in Section 4.1.2.1. The Affected Environment sections of Chapter 3 describe the ongoing effects to each resource or the effects of present actions to each resource. The Environmental Consequences sections of Chapter 3 present the direct and indirect effects of the Proposed Action and alternatives on each resource. This chapter considers the direct and indirect effects on each resource of the Proposed Action and alternatives together with the past, present, and reasonably foreseeable future actions (RFFAs) of other projects. For example, the existing and projected future climate of the Willamette River Basin (WRB) can be considered an effect of past, present, and future actions, all of which may result in further cumulative effects on certain resources in the analysis area. Note that the direct and indirect effects of climate change on all affected resources are also analyzed and discussed and qualitatively analyzed in Chapter 3.

### 4.1.1 Geographical and Temporal Scope

The geographic boundary for each resource considered in these cumulative effects analysis is referred to as the cumulative effects analysis area (CEAA). The CEAA follows the geographic boundaries of direct and indirect effects for each resource identified in Chapter 3 unless noted otherwise for specific resources.

The temporal boundaries for cumulative effects in this analysis have three components – past, present, and future. Past cumulative effects are generally captured under each resource's Affected Environment section in Chapter 3, given that past actions and their effects have contributed to the current condition of a resource. A brief description of relevant past actions is provided below, and generally include past cumulative effects dating back to approximately the year 1969 – or the year that all 13 WVS dams and reservoirs were completed. Present and reasonably foreseeable future cumulative actions are included in this chapter if they are expected to overlap in space and time with the scope of this PEIS, which unless otherwise noted is approximately the year 2050.

### 4.1.2 Cumulative Actions Scenario

The following sections discuss the past, present, and reasonably foreseeable future actions within the WRB.

#### *4.1.2.1 Past Actions*

According to CEQ, a cumulative effects analysis may assess past actions in the project area by focusing on the "current aggregate effects of past actions without delving into the historical details of individual past actions" (CEQ 2005). While all past actions do not need to be identified for the cumulative effects analysis, this section presents a brief description of the effects from past actions – including WVS dams and reservoirs and development and population growth – to the extent that they are relevant and useful in analyzing cumulative effects. Human actions and development have substantially influenced the CEAA for nearly all of the resources analyzed in this Draft PEIS. The history of the Willamette Valley System (WVS) and its component dams, reservoirs, riverbank protection, fish hatcheries, and other facilities as relevant to the proposed project is discussed in Chapters 1 and 2.

##### *4.1.2.1.1 WVS and Other Dams and Reservoirs in the WRB*

Within the analysis area, aquatic, riparian, and floodplain habitat has changed continuously throughout history through habitat loss, modification, degradation, and restoration, as a result of both natural forces and events and human activities. Central to these changes have been the alteration of the Willamette River Basin's hydrology, or how water movement has changed over time. Before dams existed in the WRB, the Willamette River was a natural, free-flowing riverine system. River flows, naturally augmented by rainfall and snowmelt, tended to be higher in the winter months and lower in the summer months.

As a result of construction of the WVS, scores of miles of free-flowing, riverine habitat in Willamette River tributaries have been converted to 13 dams and reservoirs which moderate overall flows and have changed water currents or flows. WVS operations have led to winter flows that are lower on average than historic flows because WVS reservoirs reduce high flows by capturing runoff and releasing it gradually. Average summer flows are now higher than historical summer flows as a result of intentional releases of stored water from reservoirs.

In addition to the 13 USACE-built and managed dams in the WRB, according to USACE's National Inventory of Dams, there are 247 other dams dispersed throughout the WRB managed by entities other than the USACE (USACE, 2020h). Most of these non-USACE dams are more than 50 years old, and most are small to medium-sized, with relatively few large dams and reservoirs. The majority of dams are below 30 feet in height, and only a relative few have water storage capacity that exceeds 1,000 acre-feet. Most have under 500 ac-ft of storage capacity, and many less than 100 ac-ft. (In contrast, the largest of the WVS reservoirs – Lookout Point – contains more than 400,000 ac-ft of storage.). More than 90 percent of these 247 dams are earth-fill.

Most of the dams are privately owned; some are owned by municipalities, public utilities, and the U.S. Fish and Wildlife Service or U.S. Forest Service. None of the 247 dams have flood control listed as a purpose, in contrast with the WVS dams, all but two of which have flood control as an authorized purpose. Most on the non-USACE dams were built for irrigation, recreation, fish and wildlife, and to a smaller extent, hydroelectricity and M&I water supply. Of the 247 non-USACE dams in the WRB in its entirety, only 38 dams are located in WRB sub-basins containing WVS dams/reservoirs. Along with USACE's dams and reservoirs, these widely dispersed impoundments – and more often located in the headwaters of tributaries rather mainstems of Willamette tributaries – affect the WRB's hydrology and salmon runs by obstructing migration and submerging spawning and rearing habitat. They also support the basin's increasing human population and economic activity by supplying water for both agricultural irrigation and municipal/industrial users, generating electricity, and furnishing water-based recreational opportunities for the basin's residents and visitors.

Implementation of this large suite actions has had cumulative adverse effects to resources within the WRB, including direct mortality to species and habitat loss and degradation. Examples of the various ways that habitat can be lost or degraded include the creation of barriers to fish passage both upstream and downstream; overharvest of aquatic species; introduction of invasive and predatory species; modification of flow and water temperature to suboptimal conditions; and pollution of water.

Relevant past cumulative actions also include the voluntary and federal- and state-mandated actions of private and public parties to provide beneficial and offsetting effects for salmonids, other aquatic species, and other wildlife. These offsetting actions include but are not limited to managing hatcheries and fisheries; water quality; and land, including fish and wildlife habitat. Chapters 1 and 2 of this Draft PEIS describe the ongoing collaborative efforts undertaken over the decades by the U.S. Army Corps of Engineers (USACE), Bonneville Power Administration (BPA), and the Bureau of Reclamation (Reclamation) with partnering federal, tribal, and state agencies and non-governmental organizations (NGOs) to conserve and manage fish and wildlife and mitigate the adverse effects of WVS operations. The 2008 U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) Biological Opinions (2008 BiOps) obligate USACE, BPA, and Reclamation to develop and implement procedures and measures to protect Endangered Species Act (ESA)-listed species. These measures must be concurrent with continued operations and maintenance (O&M) of the WVS in accordance with its authorized purposes.

###### *4.1.2.1.2 WRB Population Growth and Development*

In the recent past, the WRB has experienced substantial population growth and development, as shown in Figure 4.1-1. This is especially true in the lower elevations of the WRB closer to the mainstem Willamette River and its major tributaries. Other past cumulative actions related to WRB population growth and development include the following:

- Agricultural, urban, and transportation corridor development, which converts and permanently alters natural habitats;
- Water withdrawals for irrigation, municipal, and industrial uses to support human development in the Willamette Valley;
- Floodplain development;
- Logging and mining within the watershed;
- Dredging and sediment management;
- Commercial and recreational fish harvesting;
- Increase in recreational use and visitation of public lands;
- Proliferation of invasive species (both plants and animals); and
- Point and non-point source water pollution.

This growth and development have had adverse effects to resources within the WRB, including salmonids, other aquatic organisms, and other wildlife and their habitats.


**Figure 4.1-1. Population and Urban Development Increasing Throughout the WRB (Eugene, OR) (Maciek Lulko, licensed under CC BY-NC 2.0)**

According to data from the National Resources Inventory (NRI) of the U.S. Department of Agriculture's (USDA's) Natural Resources Conservation Service (NRCS), in the 35-year span between 1982 and 2017, the area of developed land in the 10 counties comprising almost all of the geographic area of the WRB grew from 519,800 acres (812 square miles) to 747,100 acres (1,167 square miles), an increase of 44 percent as shown in Table 4.1-1 (NRCS 2020). During the same time period, the combined populations of these 10 counties grew by 59 percent (USCB 1992; USCB 2020). Primarily as a result of this population growth and the associated demand for additional developed land, cropland in the 10 WRB counties listed in Table 4.1-2 decreased by 12 percent from 1982 to 2017, from 1,085,200 acres (1,696 square miles) to 955,300 acres (1,493 square miles).

**Table 4.1-1. Increase in Developed Land in WRB Counties, 1982 – 2017**

| County | 1982 Developed Land Area (1,000 acres) | 2017 Developed Land Area (1,000 acres) | Percentage Change 1982 to 2017 |
|---|---|---|---|
| Benton | 24.4 | 30.2 | 24% |
| Clackamas | 70.4 | 114.3 | 62% |
| Douglas | 57.5 | 72.8 | 27% |
| Lane | 110.7 | 141.7 | 28% |
| Linn | 40.2 | 60.5 | 50% |

| County | 1982 Developed Land Area (1,000 acres) | 2017 Developed Land Area (1,000 acres) | Percentage Change 1982 to 2017 |
|---|---|---|---|
| Marion | 58.2 | 92.3 | 59% |
| Multnomah | 70.7 | 92.5 | 31% |
| Polk | 17.4 | 26.2 | 51% |
| Washington | 52.9 | 90.9 | 72% |
| Yamhill | 17.4 | 25.7 | 48% |
| **Total** | **519.8** | **747.1** | **44%** |

Source: NRCS 2020

**Table 4.1-2. Cropland Change in WRB Counties, 1982 – 2017**

| County | 1982 Cropland Area (1,000 acres) | 2017 Cropland Area (1,000 acres) | Percentage Change 1982 to 2017 |
|---|---|---|---|
| Benton | 68.5 | 63.7 | -7% |
| Clackamas | 85.3 | 52.4 | -39% |
| Douglas | 29.6 | 31.2 | 5% |
| Lane | 114.4 | 82.3 | -28% |
| Linn | 210.3 | 214.5 | 2% |
| Marion | 244.0 | 223.6 | -8% |
| Multnomah | 16.0 | 11.3 | -29% |
| Polk | 114.5 | 112.9 | -1% |
| Washington | 76.4 | 57.8 | -24% |
| Yamhill | 126.2 | 105.6 | -16% |
| **Total** | 1,085.2 | 955.3 | -12% |

Source: NRCS 2020

#### *4.1.2.2 Ongoing and Present Actions*

As discussed in Chapter 1, Section 1.8.10, in September 2021, the U.S. District Court for the District of Oregon issued an interim injunction concerning USACE's management and operation of the WVS and effects on ESA-listed salmonids. The U.S. District Court for the District of Oregon ordered 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 until the completion of the reinitiated Section 7 ESA consultation with NMFS and USFWS.

These interim actions include 16 Near-Term Operations Measures that require changes to how one or more of the WVS dams are currently operated and three projects that modify existing WVS structures. The 16 Near-Term Operations Measures are included in each of the action alternatives described in Chapter 2, and their direct and indirect environmental effects are assessed in Chapter 3.

The three projects that modify existing WVS structures include:

- **Dexter** – Design and construct upgrades to the existing Dexter adult fish facility (AFF).
- **Big Cliff** – Determine whether operational measures alone are sufficient to maintain acceptable TDG levels below Big Cliff Dam and, if not, design and construct a structural solution for mitigating excess TDG levels during spill operations.
- **Cougar** – Determine whether structural improvements/modifications need to be made to Cougar Dam's ROs to ensure safer fish passage and reduce TDG levels and, if so, design and construct a structural solution.

The District Court ordered that the design, construction, and operation of these three structural improvement projects be expedited. Therefore, these three structural Court-ordered projects have or are currently undergoing separate NEPA processes that will assess their direct, indirect, and cumulative impacts on the human environment. Since the direct and indirect of these projects is being fully assessed by their individual NEPA documents, they are not included in Chapter 3 of this PEIS. However, this chapter includes the construction, operations, and maintenance of these reasonably foreseeable projects in the cumulative effects analysis.

As part of its comprehensive dam safety program, USACE is continuously assessing its dams to better understand dam safety risks and inform future actions. The USACE Dam Safety Program periodically assesses and reassesses risks to all our dams on a 5-year cycle. When risks are identified there is a proscribed process for elevating them for more detailed analysis and design to ensure they are adequately addressed. The assessment process identifies and analyzes many risks using the latest science and engineering methods and standards. This process is described in more detail in Appendix H. Many of the risks analyzed end up being either not consequential or probable enough to merit further action.

However, in 2020, after completing a detailed analysis of the seismic risk at Detroit and Lookout Point Dams, it was concluded that immediate action to mitigate the risk at these dams was necessary. Per Engineering Regulation, ER 1110-2-1156 (USACE Publications), "USACE has specific public safety responsibility, when a project has known safety issues, to take appropriate interim risk reduction measures including reservoir releases. USACE statutory responsibilities require operation of dams in a manner that reduces the project's probabilities of failure when there are known issues with the integrity of the project." This determination resulted in the development of Interim Risk Reduction Measures (IRRM) to address these risks until a permanent solution could be assessed and designed. IRRMs at these dams required pool restriction on the maximum pool elevation. In other words, the maximum elevation the associated reservoirs are allowed to reach each summer is lower than the authorized maximum.

The effects of these IRRMs were assessed in Environmental Assessments and are incorporated by reference. However, the measures proposed under the action alternatives do not require these reservoirs to reach the authorized maximum conservation pool elevation and, in fact, generally further restrict maximum elevations below the IRRM restrictions. Therefore, the measure in the action alternatives make it more likely that operations will meet the IRRM requirements. For this reason, the effects of the IRRMs and the measures in the action alternatives are not additive and will not be assessed further in the cumulative effects analysis.

In addition to USACE's ongoing management and operation of the WVS, present actions have already been incorporated into the affected environment for each resource analyzed in this Draft PEIS. Non-USACE actions include the operation of hydroelectric dams; recreation; timber and logging industry operations; mining operations; ongoing non-point source pollution; and management, conservation, and protection of the environment by federal and state agencies.

The alternatives analysis of this Draft PEIS assumes that existing laws, policies, agency jurisdictions, rulings, BiOps, and other elements of the regulatory environment will remain in place for their stated duration.

Likewise, while the adequacy and status of existing regional coordination, alignment, and planning actions will not be assessed in this PEIS, they nonetheless merit mention for context. For example, efforts are underway to create more integrated and regional approaches to salmon and steelhead challenges that require collaboration across federal, state and tribal government jurisdictions (e.g., Columbia Basin Partnership Taskforce, Willamette Fish Passage Operations & Maintenance coordination team, Flow Management and Water Quality Team). Anticipated future effects of these activities are included in this chapter where applicable and cumulative effects are analyzed for reasonably foreseeable future actions (RFFAs).

#### *4.1.2.3 Reasonably Foreseeable Future Actions*

RFFAs are anticipated future environmental trends or specific proposed activities that could cause similar effects in the same space and time as the no action alternative and action alternatives, but that are proposed by or involve outside entities such as other federal, state, or local agencies, or private sector interests. RFFAs can also be trends or actions that are not yet implemented. In order to be deemed reasonably foreseeable, RFFAs must typically be budgeted for and included under formal proposals or decisions (such as an official agency decision document or a county land use plan).

The RFFAs for the WVS and WRB have been grouped into eleven categories as shown in Table 4.1-3 below and are numbered for reference throughout this chapter. These cumulative actions and trends are focused on the management of fish and wildlife (primarily fish); environmental management and implementation of current and new laws, and policies; water quality and quantity management; industrial and agricultural development; regional population growth; energy development; climate change; and resource extraction.

**Table 4.1-3. Reasonably Foreseeable Future Actions Affecting the WVS and WRB**

| RFFA Number | RFFA Description |
|---|---|
| RFFA 1 | Future population growth and accompanying urban, industrial, and commercial development |
| RFFA 2 | Reduced agricultural production |
| RFFA 3 | Water withdrawals for municipal, industrial, and agricultural uses |
| RFFA 4 | Decarbonizing the energy sector with renewable energy sources |
| RFFA 5 | Federal and state wildlife and lands management |
| RFFA 6 | Fishery management and killer whales |
| RFFA 7 | Tribal, state, and local fish and wildlife improvement |
| RFFA 8 | Invasive species management |
| RFFA 9 | Climate change |
| RFFA 10 | Mining operations |
| RFFA 11 | Timber and logging industry operations |

#### *4.1.2.3.1 RFFA 1 – Future Population Growth and Accompanying Urban, Industrial, and Commercial Development*

Within the counties that compose the WRB, human populations are continuing to increase. This growth is occurring primarily in urban metropolitan areas with smaller increases in rural areas. The State of Oregon Office of Economic Analysis, responsible for making official demographic projections for Oregon, anticipates this increase to continue at least through 2050 (State of Oregon 2013). Population projections from 2020 to 2050 are shown in Table 4.1-4 for the 10 counties that compose almost the entire WRB.

**Table 4.1-4. Population Projections for WRB Counties, 2020 – 2050**

| County | 2020 Population Estimate | 2050 Population Estimate | Percentage Increase 2020 to 2050 |
|---|---|---|---|
| Benton | 91,379 | 111,666 | 22% |
| Clackamas | 422,576 | 583,814 | 38% |
| Douglas | 116,113 | 139,675 | 20% |
| Lane | 378,335 | 464,839 | 23% |
| Linn | 128,454 | 168,189 | 31% |
| Marion | 331,643 | 498,624 | 50% |
| Multnomah | 807,198 | 982,504 | 22% |
| Polk | 88,081 | 135,877 | 54% |
| Washington | 570,672 | 915,979 | 61% |
| Yamhill | 113,611 | 167,300 | 47% |

| County | 2020 Population Estimate | 2050 Population Estimate | Percentage Increase 2020 to 2050 |
|---|---|---|---|
| **Total** | **3,048,061** | **4,168,466** | **37%** |

Source: State of Oregon 2013

Projected population increases for these WRB counties range from 20 percent to 61 percent and average 37 percent. If the relationship between the increase in population and the increase in developed land continues into the future, and mirrors the trend that existed from 1982 to 2017, developed land area of the WRB from 2020 to 2050 would be estimated to increase by 28 percent, or approximately 206,150 acres (322 square miles).

A larger population in the WRB would cause a number of cascading effects throughout the basin. Municipal water demands may increase, which may be met by increased withdrawals from the WVS. Increased urban development would decrease upland habitat and increase impervious surface in the area, changing the physical, chemical, hydrological, and ecological characteristics of stream ecosystems. In most cases, such changes are detrimental to native fish and wildlife. The rate of exurban (area just beyond denser suburbs) development also appears to be increasing. Exurban development is generally associated with direct habitat conversion and loss for fish and wildlife species. Human population growth and development often leads to increased discharges of non-point source pollutants in stormwater runoff from residential, commercial, industrial, agricultural, recreational, and transportation land uses.

A variety of population-driven factors external to the WRB can also cause effects within the basin. Growing international trade through shipping has led to modifications to the lower Columbia and Willamette rivers through dredging, port development, and increasing boat traffic. Projects to deepen channels or modify ports in Portland, OR may necessitate increasing numbers of ships and cargo tonnage on the lower Willamette and increasing rail freight and truck traffic on transportation corridors in the WRB that are linked to that port. Increased volumes of materials such as hazardous products and fuels that power trains, vessels, and trucks will likely move through the WRB in response to the demands of a growing population. With increased movement of raw materials and manufactured goods via all three modes, more accidents and spills would be likely. Mining, logging, trade, and transportation projects also influence the hydrology, water quality, and land use in the WRB and WVS. Overall, this RFFA interacts cumulatively with all of the resources listed in Table 4.1-6**.**

##### *4.1.2.3.4 RFFA 2 – Reduced Agricultural Production*

Human population growth and related development have contributed to the decline of agricultural lands within the WRB. The NRCS identifies and inventories three categories of farmland or agricultural land: cropland, pastureland, and rangeland. Cropland includes cultivated row crops and orchards. Range and pasture lands are where the primary vegetation is herbaceous plants and shrubs, which provide forage for domestic livestock. As shown in Table 4.1-2, cropland in the 10 counties that compose most of the geographic area of the WRB declined by 12 percent from 1982 to 2017. Farmland seen in Figure 4.1-2 was converted to developed land to accommodate population growth.

Given the population projections shown in Table 4.1-4 that show strong growth for each of the 10 counties, land conversion and development pressures are likely to continue and the area of cropland within the WRB will likely continue to diminish. Reduced cropland acreage may reduce demands for agricultural irrigation water withdrawn from the WRB. Less cropland could also result in less soil erosion from wind and rain. Overall, this RFFA interacts cumulatively with most of the resources listed in Table 4.1-6, including but not limited to land use, soils, wetlands, listed species and critical habitat, socioeconomics, water supply, and visual resources.

**Figure 4.1-2. Willamette Valley Cropland (jim.choate59 licensed under CC BY-NC-ND 2.0)**

#### *4.1.2.3.3 RFFA 3 – Water Withdrawals for Municipal, Industrial, and Agricultural Uses*

Water usage within the WRB is likely to increase in the future, especially as human population growth, associated development, and climate change continue to affect water availability and scarcity in the region. The Willamette Water 2100 project identifies and quantifies linkages and feedbacks among human, hydrological, and ecological dimensions within the WRB, and makes predictions about where and when human activities and climate change would impact future water scarcities. Figure 4.1-3 illustrates their model's prediction on basin-wide water allocation regarding irrigation, municipal, and residential usage from 2010 to 2100. It suggests that water demand for irrigation usage (as seen in green) would remain relatively stable over the course of the 21st century; whereas water demand for municipal and residential usage (as seen in blue) would increase, likely linked to factors such as increasing human population projections and the evolving effects of climate change (WW2100 No Date).

By reducing the amount of water flowing through the WVS, increased withdrawals have implications for instream flow and for maintenance of riparian and aquatic habitats for fish and wildlife. New water withdrawals are typically subject to regulatory restrictions which might partially offset their negative effects. In the model's scenario, urban areas in general would be able to meet water needs with existing water rights, which would also include maintaining important water sources from outside the basin, such as the Bull Run watershed that supplies the City of Portland (WW2100 No Date). Overall, this RFFA interacts cumulatively with most of the resources listed in Table 4.1-6, including but not limited to water supply, socioeconomics, listed species and critical habitat, water quality, and hydrological processes.

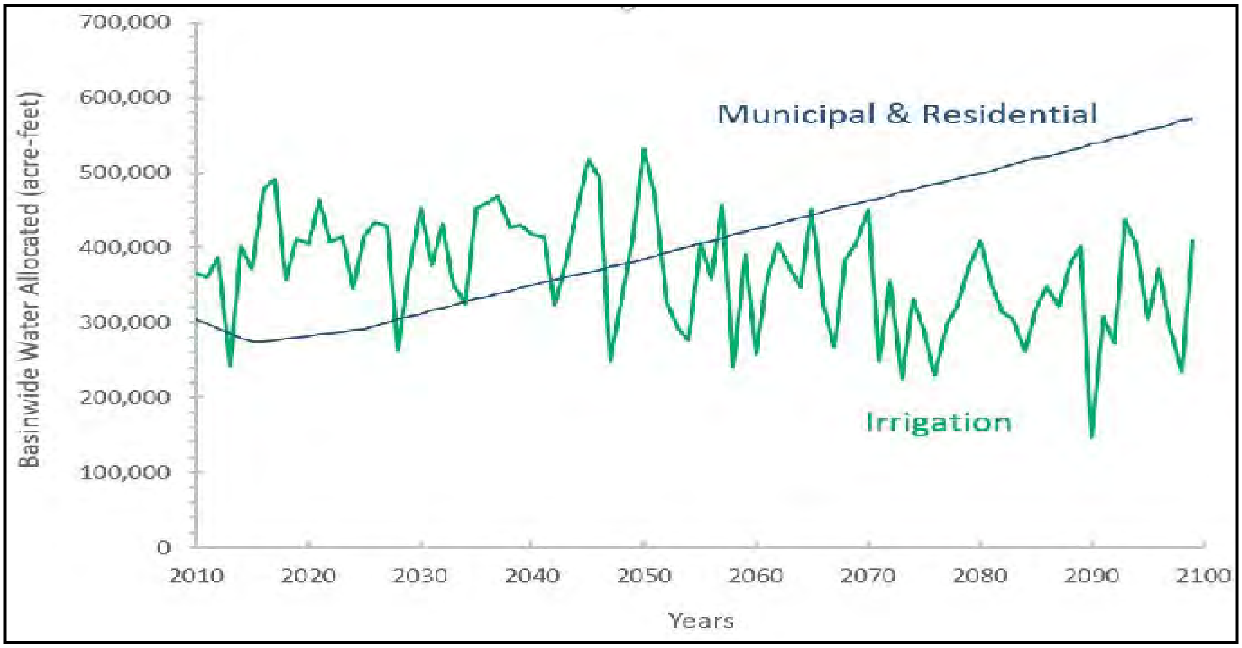


**Figure 4.1-3. WRB Water Usage Projections, 2010 – 2100 (WW2100 No Date)**

#### *4.1.2.3.4 RFFA 4 – Decarbonizing the Energy Sector with Renewable Energy Sources*

Decarbonization of the energy sector is a national trend that continues to surge in Oregon. Oregon's Renewable Portfolio Standard sets the requirement for how much of the state's electricity must come from renewable sources. In March 2016, this standard was set to require 50 percent of Oregon's electricity to come from renewables by 2040 (ODOE No Date-b). Hydropower facilities typically provide more than half of the electricity generated in Oregon; natural gas fuels the second-largest share of Oregon's electricity generation, while non-hydroelectric renewable resources, including wind, biomass, solar, and geothermal power, provide almost the rest of Oregon's generation. Coal no longer supplies any in-state generation because Oregon's only coal-fired power plant in Morrow County closed in October 2020. There are also no commercial nuclear power plants in the state (EIA 2021). Therefore, natural gas contends as the main energy generator of GHG emissions; however, no new natural gas plants have been proposed within the counties of the WRB. The Troutdale Reynolds Industrial Park in Multnomah County was terminated in 2016 when the developer withdrew the application for site certification (ODOE No Date-a). Oregon has only minor fossil energy reserves (EIA 2021), which would likely reduce the propensity for the fuel source into the future.

Renewable energy infrastructure and projects such as wind turbines and solar arrays are expanding in Oregon as throughout the nation. In the WRB and the rest of Oregon, there are federal and state wind energy incentives, including state tax credits and large cash rebates, for installing wind turbines and generators (Dasolar.com 2021; Energy Trust 2014; ODOE No Date-c). Electricity generated by renewable sources at locations outside the WRB could also potentially help meet some of the region's growing energy needs (Musial et al. 2019). However, other land use planning and regulation make it difficult to site utility-scale solar projects in the densely populated Willamette Valley, despite the fact that the high-population-growth WRB has the greatest and fastest growing electricity demand in the state (Poehler 2020). These rules do not interfere with the installation of rooftop solar arrays on existing buildings, however, which do not take up additional space in areas with competing land uses. While there are multiple renewable energy projects proposed throughout Oregon, there are currently no proposed renewable energy projects within the counties representing the WRB (ODOE No Date-a). Overall, this RFFA interacts cumulatively with most of the resources listed in Table 4.1-6, including but not limited to soils, vegetation, socioeconomics, power and transmission, land use, cultural resources, and visual resources.

#### *4.1.2.3.5 RFFA 5 – Federal and State Wildlife and Lands Management*

Public lands in Oregon continue to be managed in a way that balances economic interest with the need for wildlife conservation and land preservation. Oregon's Department of Land Conservation and Development (ODLCD) guide these decisions using the Oregon Statewide Planning Goals and Guidelines, which was recently amended in July 2019. This most recent revision includes goals to preserve forest lands, agricultural lands, scenic and historic areas; maintain air, water, and land resource quality; project urban growth boundaries for future urbanization growth; create a 300-mile Willamette Greenway that protects the Willamette River; and classify Oregon's 22 major estuaries based on their biological, economic, recreational, and aesthetic benefits to better inform future developments or alterations. Local city and county land use plans must be consistent with the statewide planning goals, thereby becoming the controlling document for land use in the area covered by that plan (ODLCD 2019).

The WRB contains abundant public lands, especially in the headwaters and higher elevations. These lands would continue to be managed for multiple purposes, such as watershed protection, wildlife and habitat conservation, recreation, livestock grazing, resource extraction (e.g., logging, mining), and other public uses. The 1.7-million-acre Willamette National Forest as shown in Figure 4.1-4 contains eight Congressionally-designated national wilderness areas and stretches for 110 miles along the eastern edge of the WRB and western slopes of the Cascade Range. The forest extends from the upper reaches of the Santiam River in the north and past the McKenzie River, to the Middle and North Forks of the Willamette and the 8,743-ft. Diamond Peak in the south. Among other functions, its wooded slopes provide the cities of Salem, Eugene, and Springfield, and other communities in the WRB with clear, clean water by serving as a sponge and protecting soils from erosion (USFS No Date-b). Mt. Hood National Forest extends from the northern boundary of the Willamette National Forest northward towards the City of Portland and the Columbia River. It contains more than a million acres of forested mountains, lakes, and streams (USFS No Date-a).

**Figure 4.1-4. Willamette National Forest**

The Oregon Department of Fish and Wildlife (ODFW) and the U.S. Fish and Wildlife Service (USFWS) would continue to implement management activities at the Willamette Valley National Wildlife Refuge Complex. The three refugees that make up the complex include William L. Finley National Wildlife Refuge, Ankeny National Wildlife Refuge, and Baskett Slough National Wildlife Refuge, located in Benton, Marion, and Polk counties, respectively. The three refuges in the complex provide protection for historically abundant oak savanna, native prairie, riparian forest, and wetland habitats. These protected areas allow endangered plant populations to grow, summer songbirds to nest, and wintering waterfowl to find sanctuary in the vast wetlands. Refuges are grouped and managed as a "complex" because they occur in a similar ecological region, such as a watershed or specific habitat type (USFWS 2014). In addition to conserving and managing wildlife habitats and populations, national wildlife refuges foster six priority public uses, namely hunting, fishing, wildlife observation, wildlife photography, environmental education, and interpretation.

The way that these lands are managed within the WRB can have cumulative effects when added to the actions proposed in this Draft PEIS. In particular, water management, soil management, vegetation management, and fire management can have important additive effects that could be either beneficial or adverse depending on the nature of the management action.

Section 3.9 of this EIS refers to a number of species currently listed as threatened or endangered under the federal Endangered Species Act, some of whom for which critical habitat has been designated. Also mentioned are certain candidate species, species petitioned for listing, and species of concern. In the future, if any of these other species are formally listed under the ESA and afforded additional protections (such as critical habitat designation), this could potentially constrain certain proposed operational or structural measures at specific projects in the WVS.

Overall, this RFFA interacts cumulatively with most of the resources listed in Table 4.1-6, including but not limited to land use, water and air quality, socioeconomics, flood risk management, water supply, recreation, listed species and critical habitat, hazardous algal blooms, tribal and cultural resources, and environmental justice.

##### *4.1.2.3.6 RFFA 6 – Fishery Management and Killer Whales*

The management of killer whales and the fisheries they depend on are expected to continue into the future based on the efforts taken by the Pacific Fishery Management Council (PFMC) and other stakeholders concerned about their survival. PFMC, one of eight regional fishery management councils established by Congress in 1976, manages ocean populations of Upper Willamette River (UWR) Chinook salmon, which are the focus of multi-agency endangered species preservation efforts in the WVS. The PFMC prepares fisheries harvest plans known as Pacific Salmon Fishery Management Plans for Chinook (including UWR Chinook), coho, and pink salmon; these plans are implemented and enforced by NMFS in federal offshore waters (i.e., 3 to 200 miles offshore). NMFS promulgates regulations for how many salmon can be caught offshore based on PFMC plans. Overall, the PFMC and NMFS are studying ways to better manage the catch of salmon in offshore ocean waters.

PFMC established the Southern Resident Killer Whale (SRKW) Workgroup to reassess the effects of federal ocean salmon fisheries on southern resident killer whales as seen in Figure 4.1-5. The goal of the workgroup was to potentially recommend conservation measures or management protocols that limit the effects on Chinook salmon, including UWR Chinook, in federal waters, and thereby indirectly help ensure the survival of the highly endangered SRKW. The southern resident killer whales compose the smallest of the three “resident” populations of killer whales in the eastern North Pacific Ocean. As of September 2020, they numbered just 74 individuals in three pods, down from 96-98 individuals in the mid-1990s. Southern resident killer whales are found mostly off British Columbia, Washington and Oregon, but also travel to forage widely along the outer coast. Southern residents specialize in preying on Chinook salmon. They feed on Chinook year-round, and this species is their main prey in the spring and summer when they occupy inland waters (MMC 2021).

**Figure 4.1-5. Pod of Killer Whales (*Orcinus orca*)**

The SRKW Workgroup is composed of representatives from West Coast tribes; the states of California, Idaho, Oregon, and Washington; PFMC; and NMFS. In November 2020, the workgroup provided recommendations for ocean salmon fisheries management via a final report to PFMC members (PFMC 2020). Under the plan adopted by PFMC, the management threshold was set as the arithmetic mean of the seven lowest years of pre-fishing Chinook salmon abundance in the area north of Cape Falcon, Oregon (1994-1996, 1998-2000, and 2007, currently estimated at 966,000). When any given year's preseason Chinook abundance projection falls below the established threshold of 966,000, a number of management actions (time and area fishery closures) are implemented through annual regulations. These management efforts interact cumulatively with the number of UWR Chinook salmon able to return each year to spawn in Willamette River tributaries via the Columbia River and the mainstem Willamette.

In other words, ocean fisheries have an effect (a reduction) on adult salmon returns via removal of fish by harvest. However, in the case of UWR Chinook in PFMC fisheries, only minimally so given an average exploitation rate in PFMC fisheries of less than 0.5%. Actions in the PFMC ocean fishery management areas have very low effects on the return abundance of UWR Chinook. Therefore, the magnitude of effect on SRKW of ocean fishery actions on UWR Chinook is also very small. However, UWR Chinook are important to SRKW due to the timing of their return to the mouth of the Columbia and energetic need for SRKW in that time period. In contrast to PFMC fisheries management actions, measures that improve production of the salmon stock in freshwater areas can have a potentially large effect on the strength of the return, and thereby would be expected to accrue larger benefits to SRKW in comparison. Furthermore, in the absence of significant improvements in smolt-to-adult ratios of natural-origin fish, any reductions in Willamette Valley hatchery production would directly reduce key food resources available to the SRKW.

Overall, this RFFA interacts cumulatively with most of the resources listed in Table 4.1-6, including socioeconomics, recreation, tribal resources, listed species and critical habitat, wetlands, and water quality.

#### *4.1.2.3.7 RFFA 7 – Tribal, State, and Local Fish and Wildlife Improvement*

State and local agencies, tribes, environmental organizations, and private communities are expected to continue non-federal habitat activities and projects focused on improving general habitat and ecosystem function or species-specific conservation objectives. ODFW created their Strategic Plan in February 2018 to establish their long-term goals of managing and protecting the state's fish and wildlife resources, both game and nongame. One of their main goals is to expand stewardship and support of Oregon's fish, wildlife, and their habitats. To accomplish this, ODFW plans to continue effective stewardship of Oregon's fish, wildlife, and their habitats through sound science and by addressing constituents' needs, providing leadership on five focal fish and wildlife issues with progress reports and solutions by 2022, aligning budgets with ODFW conservation and management priorities, and expanding ODFW overall funding efforts (ODFW 2018).

The Confederated Tribes of Grand Ronde Community of Oregon collaborates with USACE to improve fish habitat and populations in Reservation streams, in part for subsistence fishing purposes. Members of the Confederated Tribes of Warm Springs harvest Pacific lamprey at Willamette Falls and work with USACE to ensure that cumulative effects from other ongoing projects or mitigation efforts in the WRB are taken into account. Members also coordinate with USACE to consider potential effects of the WVS on water quality, climate change, streamflow for fish and wildlife, and tribal cultural resources, in particular on Pacific salmon and lamprey.

The Nature Conservancy (TNC) carries out a number of projects in the WRB oriented toward protecting imperiled species, management of habitats and ecosystems, and adapting to climate change. One of their most recent projects was the restoration of the Willamette River at the confluence of the middle fork of the Willamette River and the coastal fork, east of Eugene. TNC removed a series of gravel pits and barriers acting as levees and allowed the river to return to its natural, free-flowing state, which provided crucial resting spots for salmon, wetland habitat for wildlife, and fertile floodplains for trees, shrubs, and other plants. The McKenzie River Trust owns and manages the property, and continues to collaborate with TNC on preservation projects and ecotourism programs (TNC 2021). Overall, this RFFA interacts cumulatively with most of the resources listed in Table 4.1-6, including but not limited to water and air quality, socioeconomics, recreation, land use, visual resources, tribal and cultural resources, hydrologic processes, and environmental justice.

#### *4.1.2.3.8 RFFA 8 – Invasive Species Management*

Non-native and invasive plants and animals are damaging biological diversity and ecosystem integrity across the WRB. Aquatic species such as water primrose and yellow floating heart are of particular concern because they can spread rapidly and can quickly alter the function of an ecosystem. Within the Willamette Valley National Wildlife Refuge Complex, several invasive species pose a serious threat to native species through competition and predation. Reed canarygrass out-compete native wetland emergent plants; Himalayan blackberry thickets alter upland prairies and woodlands, nutria degrade aquatic habitats and displace native species; and bullfrogs, bass, and bluegill fish disrupt aquatic ecosystems by preying on native fish, amphibians, and reptiles (USFWS No Date).

Throughout the WRB, USACE, BPA, and Reclamation, the cooperating agencies listed in Chapter 1, and other federal land managers such as the USFWS and USFS cooperate on weed management, invasive species prevention and eradication, and vegetation treatments. To the extent that these efforts are successful, they improve habitats for and the survival of native plants and animals. Several other planning efforts and regulations are underway to provide a comprehensive framework for addressing invasive species in Oregon (Oregon Conservation Strategy No Date). These include:

- Oregon Statewide Strategic Plan for Invasive Species, 2017 – 2027
- ODFW Wildlife Integrity Administrative Rules
- ODFW Aquatic Invasive Species Prevention Plan
- Oregon Department of Agriculture Noxious Weed Strategic Plan
- Oregon Aquatic Nuisance Species Management Plan
- Ballast Water Management Administrative Rules

In general, USACE anticipates that invasive species management will increase in the future in the WRB generally and WVS specifically as changes in climatic conditions may favor invasive species (both native and non-native) that are early colonizers after disturbance, more resistant to climate perturbations, or favored by emerging climate regimes (such as those flora and fauna migrating northward).

Overall, this RFFA interacts cumulatively with some of the resources listed in Table 4.1-6, including but not limited to water quality, wetlands, listed species, recreation, land use, hazardous algal blooms, and drinking water.

##### *4.1.2.3.9 RFFA 9 – Climate Change*

Climate change continues to be an evolving, complex phenomena that is causing multiple, and at times intersecting, environmental effects that are occurring within the WRB, the state of Oregon, and the planet as a whole. Appendix F2, Supplemental Climate Change Information, provides a relatively detailed assessment of the potential effects of climate change on the WRB and WVS using the most recent available science and modeling. This appendix includes the results of a 4-year research project completed by the University of Washington and Oregon State University, with resource support and technical expertise provided by the River Management Joint Operating Committee (RMJOC) agencies (USACE, BPA, and Reclamation). The RMJOC-II report (2018) found the following for the 2020 to 2049 time period:

- Temperatures in the region have already warmed about 1.5 degrees Fahrenheit (°F) since the 1970s. Temperatures are expected to warm another 1 to 4°F by the 2030s.
- Future precipitation trends are more uncertain, but higher precipitation is likely for the rest of the 21st century, particularly in the winter months. Already-dry summers could become drier.
- The incidence of large forest fires as seen in Figure 4.1-6 has increased since the early 1980s and is projected to continue increasing through the 21$^{st}$ century as air surface temperatures continue to rise. Wildfire alters the land surface and can have strong influences on runoff, vegetation dynamics, erosion and sediment transport, and ecosystem processes. Strong seasonality and dependence on spring snowmelt positions the WRB to be at risk for increased fires due to the effects of climate change.
- Average winter snowpacks in the mountains surrounding the Willamette Valley are very likely to decline over time as more winter precipitation falls as rain instead of snow.
- By the 2030s, higher average fall and winter flows on WRB streams and rivers, earlier peak spring runoff, and longer periods of low summer flows are very likely.
- Overall, this RFFA interacts cumulatively with all of the resources listed in Table 4.1-6.

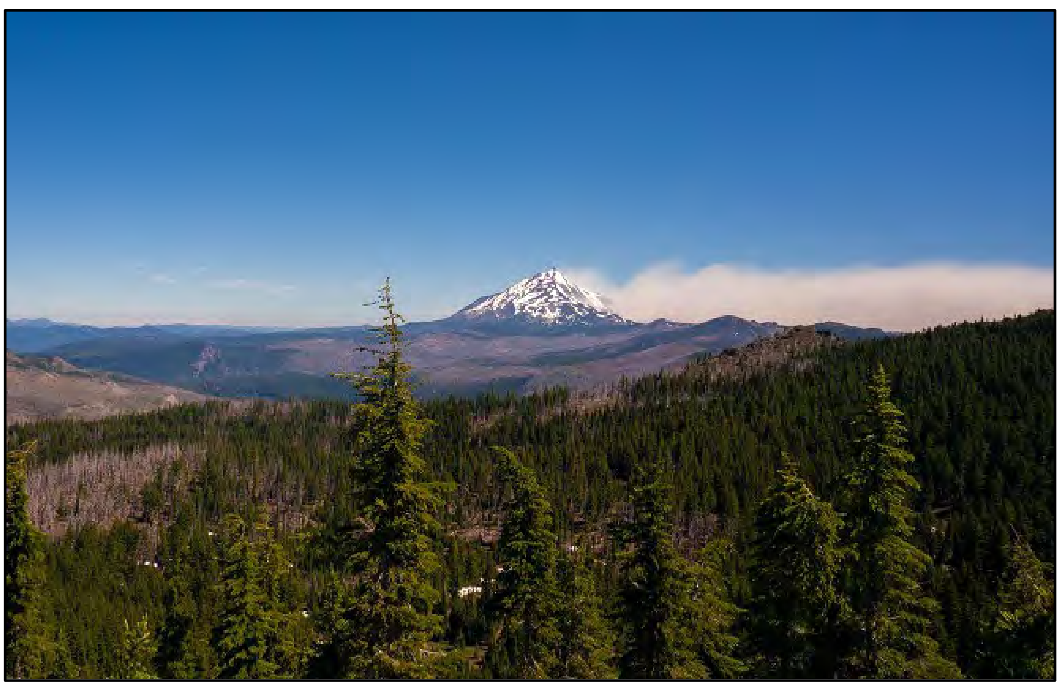

**Figure 4.1-6. Wildfires on the slopes of Mt. Jefferson in the Oregon Cascades (Travis Simpson from Pixabay)**

#### *4.1.2.3.10 RFFA 10 – Mining Operations*

Mining operations within the WRB continue to be of growing interest due to the area's diverse mineral resources and the large number of identified mines and active mining claims. The Oregon-Washington Bureau of Land Management (BLM) is responsible for a wide variety of activities within the minerals program, including decision-making regarding mining claims and providing guidance for surface use management and use and occupancy under the mining laws (BLM No Date-a). As of 2021, the WRB has a total of 462 identified mines, most of which are located within Lane, Douglas, Linn, and Clackamas counties as seen in Table 4.1-5. A majority of these mines are for minerals including but not limited to gold, silver, copper, zinc, lead, mercury, antimony, barium-barite, silica, manganese, clary, and construction sand and gravel. Of those mines, 171 (37 percent) are in production, and another 199 (43 percent) are prospect mines, meaning there has been some degree of development such as surface trenching, shafts, drill holes, or geophysical, geochemical, or geological surveys to estimate grade and tonnage (The Diggings 2022). These are likely indications of future mining activities in these counties.

Furthermore, the WRB has 691 active mining claims (The Diggings 2022), which are parcels of land that the claimant has asserted a right of possession, and the right to develop and extract a discovered, valuable, mineral deposit. The overwhelming majority of these sites are located in Douglas and Lane counties. Claimants are required to maintain their sites by paying an annual maintenance fee every year to continue to hold their mining claims, or they must perform assessment work such as drilling, excavations, driving shafts and tunnels, or geophysical, geochemical, or geological surveys (BLM No Date-b). While there is no guarantee the active claims will transition into production mines, these ongoing maintenance requirements do indicate the probability that these sites could transition to production mines in the future. Overall, this RFFA interacts cumulatively with some of the resources listed in Table 4.1-6, including but not limited to land use, hazardous materials, visual resources, noise, water and air quality, and socioeconomics.

**Table 4.1-5. Mining Sites in WRB Counties, 2021**

| County | Identified Mines | Production Mines | Prospect Mines | Active Claims |
|---|---|---|---|---|
| Benton | 1 | 0 | 0 | 0 |
| Clackamas | 52 | 22 | 21 | 3 |
| Douglas | 111 | 53 | 39 | 351 |
| Lane | 170 | 58 | 90 | 233 |
| Linn | 88 | 37 | 35 | 53 |
| Marion | 15 | 0 | 7 | 49 |
| Multnomah | 13 | 1 | 4 | 0 |
| Polk | 5 | 0 | 0 | 0 |
| Washington | 3 | 0 | 0 | 0 |
| Yamhill | 4 | 0 | 3 | 2 |

| County | Identified Mines | Production Mines | Prospect Mines | Active Claims |
|---|---|---|---|---|
| **Total** | 462 | 171 | 199 | 691 |

Source: The Diggings 2022

*4.1.2.3.11 RFFA 11 – Timber and Logging Industry Operations*

While Oregon is in one of the world's great tree-growing regions (the Pacific Northwest), trends indicate that growth has slowed recently in the timber and logging industry state wide, especially in the WRB. Oregon's soils and climate provide ideal conditions for growing commercially viable trees – which can be made into products such as paper, lumber, particle board, firewood, and oak barrels – and forests cover more than 30 million of Oregon's 62 million acres – almost half the state's landmass. However, timber harvests have fluctuated from 1990s to 2020 and decreased overall. From 1990 to 2020, annual timber harvests declined from 6.2 billion board feet to 3.6 billion board feet. Jobs from 1990 to 2019 declined by almost 41 percent from 15,774 statewide to 9,353. Projections for the Oregon logging industry predict a relatively stable but gradual decline of the industry, losing about 100 jobs, or two percent, between 2020 and 2030 (Rooney 2021).

Western Oregon is classified as one of the top timber regions of the country. Of Western Oregon's 19.2 million acres, 15.3 million acres are forested, or 80 percent. Forests in this region have about 78 billion cubic feet of standing timber. About 71 percent of this volume is in federal ownership, all of which is not available for production due to the expansion of riparian and wildlife preserves and forest conservation efforts. The other 29 percent is in nonfederal ownership, such as private industry (Campbell, Azuma, and Weyermann 2002).

The ecological units in Western Oregon include the Willamette Valley, the Oregon Coast Range, the Western Cascades, and the Klamath Mountains. The Willamette Valley would not likely be the focus of timber and logging operations into the foreseeable future. It has the lowest percentage of forest lands (35 percent) among other ecological units and also has the highest number and concentration of people (Campbell, Azuma, and Weyermann 2002). Although the WRB is not expected to be a major focus for the timber and logging industry in the future, it is included as an RFFA because of cumulative interactions with some of the resources listed in Table 4.1-6, including land use, vegetation, listed species and critical habitat, soils, visual resources, noise, and socioeconomics.

#### *4.1.2.4 RFFA Interaction with Resources*

Table 4.1-6 lists the 11 RFFAs and indicates each resource topic with which there would be a potential cumulative effect interaction.

**Table 4.1-6. Reasonably Foreseeable Future Actions and Potentially Affected Resources Matrix**

| Resource Topic | RFFA 1 | RFFA 2 | RFFA 3 | RFFA 4 | RFFA 5 | RFFA 6 | RFFA 7 | RFFA 8 | RFFA 9 | RFFA 10 | RFFA 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Processes and River Infrastructure | X | | X | | X | | X | | X | | |
| Geomorphology and Sediment Transport | X | X | X | | X | | X | | X | X | X |
| Geology and Soils | | | X | | | | X | | X | X | X |
| Water Quality | X | X | X | X | X | | X | X | X | X | |
| Vegetation (including ESA/sensitive species and critical habitat) | X | X | X | | X | | X | X | X | | X |
| Wetlands | X | X | X | | X | X | X | X | X | | |
| Fish, Aquatic Invertebrates, and Aquatic Habitat (including ESA/sensitive species and critical habitat) | X | X | X | X | X | X | X | X | X | | |
| Wildlife, Birds, and Terrestrial Habitat (including ESA/sensitive species and critical habitat) | X | X | X | X | X | X | X | X | X | X | X |
| Air Quality | X | | | X | X | | X | | X | X | |
| Climate Change | X | | | X | X | | | | X | X | X |
| Socioeconomics | X | X | X | X | X | X | X | | X | X | X |
| Power and Transmission | X | | | X | | | | | X | | |
| Flood Risk Management | X | | | | X | | X | | X | | |
| Water Supply (Irrigation, Municipal, and Industrial) | X | X | X | | X | | X | | X | | |
| Transportation/Navigation | X | | | | | | | | X | | |
| Recreation | X | | | | X | X | X | X | X | | X |
| Land Use | X | X | X | X | X | | X | X | X | X | X |
| Hazardous Materials | X | X | | X | | | | | X | X | |
| Public Health and Safety – Hazardous Algal Blooms | X | X | | | X | | X | X | X | | |
| Public Health and Safety – Hazardous Materials | X | | | X | | | | | X | X | |

| Resource Topic | RFFA 1 | RFFA 2 | RFFA 3 | RFFA 4 | RFFA 5 | RFFA 6 | RFFA 7 | RFFA 8 | RFFA 9 | RFFA 10 | RFFA 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Public Health and Safety – Drinking Water | X | X | X | | X | | X | X | X | X | |
| Environmental Justice | X | | X | | X | | X | | X | | |
| Tribal Resources | X | | X | X | X | X | X | | X | | |
| Cultural Resources | X | | | | X | | X | | X | X | X |
| Visual Resources | X | X | | X | X | | X | | X | X | X |
| Noise | X | | | X | | | | | X | X | X |

Note: RFFA 1 = Future population growth and accompanying urban, industrial, and commercial development
RFFA 2 = Reduced agricultural production
RFFA 3 = Water withdrawals for municipal, industrial, and agricultural uses
RFFA 4 = Decarbonizing the energy sector with renewable energy sources
RFFA 5 = Federal and state wildlife and lands management
RFFA 6 = Fishery management and killer whales
RFFA 7 = Tribal, state, and local fish and wildlife improvement
RFFA 8 = Invasive species management
RFFA 9 = Climate change
RFFA 10 = Mining operations
RFFA 11 = Timber and logging industry operations

## 4.2 HYDROLOGIC PROCESSES

### 4.2.1 Cumulative Effects Analysis Methodology for Hydrologic Processes

The cumulative effects on hydrologic processes are analyzed qualitatively across the WVS and within each alternative with respect to its differences from the NAA. This section considers how the cumulative actions discussed below would alter the hydrologic processes results and analysis in Chapter 3. The period of analysis is the same as this PEIS (to the 2050s).

#### *4.2.1.1 Cumulative Actions Applicable to Hydrologic Processes*

Past actions, present actions, and RFFAs that, when considered together with the Proposed Action and alternatives, would have cumulative effects on hydrologic processes, include:

- WVS and other Dams and Reservoirs in the WRB: construction and past operations and maintenance
- WRB Population Growth and Development: altered land use within to the Willamette River
- WVS Dams and Reservoirs: ongoing operations and maintenance
- RFFA 1: Future population growth and accompanying urban, industrial, and commercial development
- RFFA 3: Water withdrawals for municipal, industrial, and agricultural uses
- RFFA 5: Federal and state wildlife and lands management
- RFFA 7: Tribal, state, and local fish and wildlife improvement
- RFFA 9: Climate change

Some of the other RFFAs discussed in Section 4.1.2.3 would not interact with the hydrology of the Willamette Basin or only negligibly alter the WVS dam and reservoir operations and as such would not have a cumulative effect on Hydrologic Processes.

- RFFA 2: Reduced agricultural production. While decreased projected cropland may marginally affect Willamette Basin hydrology, the main driver of this interaction is more properly placed in RFFA 1.
- RFFA 4: Decarbonizing the energy sector with renewable energy sources. There is minimal variation in total flow due to outlet choice, such as whether to run the WVS dam’s hydroelectric turbines.
- RFFA 6: Fishery management and killer whales. The flow targets in the WVS are specific to the river reaches and habitat where they occur. They are not variable based on Pacific Ocean salmon returns.
- RFFA 8: Invasive species management. Does not affect flow or regulation decisions for the WVS dams.

- RFFA 10: Mining operations. Negligible cumulative changes to total flow in the Willamette Basin from the status quo.
- RFFA 11: Timber and logging industry operations. Negligible cumulative changes to total flow in the Willamette Basin from the status quo.

Therefore, these RFFAs are dismissed from further analysis.

#### *4.2.1.2 Cumulative Effects to Hydrologic Processes by Alternative*

The existing regulated hydrology is changed from the natural condition by the construction and operation of the WVS and other dams and reservoirs. The imposition of regulated hydrology moderated the natural hydrology in the Willamette Basin. Regulated peak flows are lower in the winter due to flood risk management operations. Flows are also lower during spring while the reservoirs store water, and higher during the summer and fall when they release that stored water. The volume and height of each reservoir and dam or system or dams and reservoirs generally determines its potential cumulative effect on the hydrology of the WRB.

Past WRB population growth and development has altered land use in the WVS watershed and next to the rivers that the WVS dams and reservoirs regulate. This development has affected the construction and operation of the WVS dams and reservoirs, with the Corps historically seeking the maximize their net benefits to the downstream population.

The WVS dams and reservoirs are currently authorized for flood control, hydropower, pollution abatement, fish and wildlife conservation, recreation, irrigation, municipal and industrial water supply, and water quality. The revetments are typically designed for riverbank stabilization, though features and functions vary by location. The typical operations within WVS have changed since their construction and continue to change with ongoing operations and actions currently in development. While each individual water year may have a minor effect on the basin-wide hydrology, ongoing changes will alter the system permanently.

Future population grow and accompanying urban, industrial, and commercial development (RFFA 1) would increase local inflow into river reaches downstream of the WVS dams and increase demand for water withdrawals consumptive uses (see RFFA 3 analysis below). The increased runoff would present flood management challenges to the WVS during flood season as there would be no increase in storage available to operate to the additional downstream inflow. The increased demand for water withdrawals would occur across all seasons. Since total flow is lower in the summer, the increase would be a greater portion of the total flow in that season. Both the flood management challenges and the increased demand for consumptive withdrawals would be additive effects.

Water withdrawals for municipal, industrial, and agricultural uses (RFFA 3) would decrease water availability and operational adaptability across many reaches of Willamette Valley basin. Increased demand would have the effect of either decreasing reservoir water surface elevation, decreasing instream flows, or a combination of both. Water withdrawals would be additive effects.

Federal and state wildlife and lands management (RFFA 6) refers to areas both upstream and downstream of the WVS reservoirs. Upstream of the reservoirs, as with the timber and mining effects (RFFAs 11 and 12), there are unlikely to be future change large enough to appreciably alter the inflow to the reservoirs. Downstream of the dams, the restoration project would increase floodplain storage at the margin, potentially altering the local inflows. This would potentially alter flood management operations and the effect would be additive.

Tribal, state, and local fish and wildlife improvement (RFFA 8) would primarily alter the Willamette Basin hydrology with the fish flow targets downstream of the WVS dams and the combined targets on the mainstem Willamette River. This PEIS contains measures that would redefine these targets. The spring and summer regulated hydrology of the Willamette River, particularly in dry years, is defined by these flow operations and any changes would be immediately noticeable. These effects would be additive.

Climate change (RFFA 10) would increase winter inflows to the Willamette basin, both upstream and downstream of the WVS dams and reservoirs, which would alter flood risk management operations during the winter and generally increase instream flows regardless of Corps actions. In late spring, basin-wide flows would drop earlier, leading to lower reservoir water surface elevations to meet ongoing and increasing flow demands. See the climate change sections of each alternative in section 3.2 for more information. Effects would be additive with the other RFFAs within their respective seasons.

In general, the combination of the RFFAs with an effect on Hydrologic Processes would increase overall flow and reservoir water surface elevations in the winter. This could either be inflow to reservoirs and streams or changes in reservoir operations as a direct consequence of those same increases. This same set of RFFAs would decrease available instream flows and reservoir water surface elevations starting in the late spring through the summer and fall.

#### *4.2.1.3 No Action Alternative*

There could be substantial changes to the existing conditions hydrologic processes in the Willamette River Basin under the No Action Alternative from the cumulative effects listed above. The combined cumulative effects in the Willamette Basin would mean higher reservoir water surface elevations and an increase in flows across all river reaches in the winter and early spring. The late spring and summer would bring lower reservoir water surfaces and lower flow in dry years, when accumulated stored water could run out more often and earlier in the year. However, the contribution of the NAA to the combined cumulative effects would be minor or negligible on its own since the NAA maintains the hydrology of the Willamette Basin consistent with existing conditions.

#### *4.2.1.4 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

The cumulative effects to hydrologic processes for Alterative 1 are divided by Willamette River subbasin based on the effects described at the top of this section. Overall, the cumulative effects to hydrologic processes would be expected to be moderate when applied to Alternative

1. During the PEIS analysis period, Alternative 1 would alter the hydrology of the WVS to a greater extent than the cumulative actions, though climate change and water withdrawals would measurably change certain aspects of the WVS operations.

#### *4.2.1.4.1 Santiam Subbasin*

The cumulative actions would decrease reservoir elevations at Detroit and Green Peter in the conservation season. Because Alternative 1 increases total storage as compared the NAA, downstream flows would remain similar even with cumulative actions such as increased downstream flow demands.

Winter would see both increased instream flows and increased reservoir water surface elevations, particularly at Detroit due to higher-than-average expected increases in inflow.

#### *4.2.1.4.2 Long Tom Subbasin*

Fern Ridge reservoir water surface elevations and downstream flows would moderately decrease during conservation season (spring to early fall) and increase during flood season (winter) from cumulative actions, including climate change and future population growth.

#### *4.2.1.4.3 McKenzie Subbasin*

Predicted conservation season reservoir water surface elevation increases at Cougar and Blue River would be offset by cumulative actions, including climate change and water withdrawals. Flow releases would also decrease in dry years but remain relatively stable in average and wetter years.

Winter would see both increased instream flows and increased reservoir water surface elevations, particularly at Cougar due to higher-than-average expected increases in inflow.

#### *4.2.1.4.4 Middle Fork of the Willamette Subbasin*

At Lookout Point and Hills Creek, increased conservation season storage would be decreased by cumulative actions, decreasing dry year flows when the reservoirs already reach their minimum water surface elevations to meet mainstem flow targets. Fall Creek reservoir water surface elevations and releases would be lower.

Winter would see both increased instream flows and increased reservoir water surface elevations, particularly at Hills Creek due to higher-than-average expected increases in inflow.

#### *4.2.1.4.5 Coast Fork of the Willamette Subbasin*

Both Dorena and Cottage Grove water surface elevations would decrease during conservation season. Since Alternative 1 increases total storage, downstream flows would remain similar.

Winter would see both increased instream flows and increased reservoir water surface elevations due to climate change, but less so than in higher elevation basins.

##### *4.2.1.4.6 Mainstem Willamette River*

Instream flows would decrease during conservation season – from late spring through early fall – due to cumulative actions including climate change and water withdrawals. Although the addition of stored water from the WVS reservoirs would offset some of this reduction, the flow targets at Albany and Salem would be missed more often during the summer and fall.

Winter flows would increase in the mainstem Willamette River in all except the driest years with climate change and population growth. The WVS operations may be able to increase average reservoir elevations during flood risk management operations to limit this increased flow. However, since most of the tributary area to the mainstem Willamette River is unregulated and increased inflows to the reservoirs would likely be coincident with the increased instream flows, the potential for winter-time reservoir management to offset increasing flows would be very limited in scope.

#### ***4.2.1.5 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative***

The cumulative effects to hydrologic processes for Alterative 2A are divided by Willamette River subbasin based on the effects described at the top of this section. Overall, the cumulative effects to hydrologic processes would be expected to be moderate within the framework of Alternative 2A. During the PEIS analysis period, Alternative 2A would alter the hydrology of the WVS to a greater extent than the cumulative actions, though climate change and water withdrawals would measurably change certain aspects of the WVS operations.

##### *4.2.1.5.1 Santiam Subbasin*

The cumulative actions would decrease reservoir elevations at Detroit and Green Peter in the conservation season. Since Alternative 2A increases total storage as compared the NAA, downstream flows would likely remain similar for all but the driest years even with actions such as increased downstream flow demands.

Winter would see both increased instream flows and increased reservoir water surface elevations, particularly at Detroit due to higher-than-average expected increases in inflow. The cumulative effects would reduce any additional winter-time flexibility after the fall drawdown at Green Peter by increasing inflows.

##### *4.2.1.5.2 Long Tom Subbasin*

Fern Ridge reservoir water surface elevations and downstream flows would moderately decrease during conservation season (spring to early fall) and increase during flood season (winter) from cumulative actions, including climate change and future population growth.

#### *4.2.1.5.3 McKenzie Subbasin*

Predicted conservation season reservoir water surface elevation increases at Cougar and Blue River would be offset by cumulative actions, including climate change and water withdraws. Summer and fall flow releases would decrease in dry years and the variability in summer flows would continue to decrease.

Winter would see both increased instream flows and increased reservoir water surface elevations, particularly at Cougar due to higher-than-average expected increases in inflow.

#### *4.2.1.5.4 Middle Fork of the Willamette Subbasin*

At Lookout Point and Hills Creek, increased conservation season storage would be decreased by cumulative actions, decreasing dry year flows when the reservoirs already reach their minimum water surface elevations to meet mainstem Willamette River flow targets. Fall Creek reservoir water surface elevations and releases would be lower.

Winter would see both increased instream flows and increased reservoir water surface elevations, particularly at Hills Creek due to higher-than-average expected increases in inflow.

#### *4.2.1.5.5 Coast Fork of the Willamette Subbasin*

Both Dorena and Cottage Grove water surface elevations would decrease during conservation season and would likely reach minimum conservation elevation in the driest years. Although Alternative 2A increases total storage, downstream flows would decrease in late fall when the reservoirs exhaust their stored water.

Winter would see both increased instream flows and increased reservoir water surface elevations due to climate change, but less so than in higher elevation basins.

#### *4.2.1.5.6 Mainstem Willamette River*

Instream flows would decrease during conservation season – from late spring through early fall – due to cumulative actions including climate change and water withdrawals. Although the additional stored water from the WVS reservoirs would offset some of this reduction, the flow targets at Albany and Salem would be missed during the driest years. Summer flow variability would further decrease.

Winter flows would increase in the mainstem Willamette River in all except the driest years with climate change and population growth. The WVS operations may be able to increase average reservoir elevations during flood risk management operations to limit this increased flow. However, since most of the tributary area to the mainstem Willamette River is unregulated and increased inflows to the reservoirs would likely be coincident with the increased instream flows, the potential for winter-time reservoir management to offset increasing flows would be very limited in scope.

#### *4.2.1.6 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

The cumulative effects to hydrologic processes for Alterative 2b are divided by Willamette River subbasin based on the effects described at the top of this section. Overall, the cumulative effects to hydrologic processes would be expected to be moderate within the framework of Alternative 2B. During the PEIS analysis period, Alternative 2B would alter the hydrology of the WVS to a greater extent than the cumulative actions, though climate change and water withdrawals would measurably change certain aspects of the WVS operations.

##### *4.2.1.6.1 Santiam Subbasin*

The cumulative actions would decrease reservoir elevations at Detroit and Green Peter in the conservation season. Since Alternative 2B increases total storage as compared the NAA, downstream flows would likely remain similar for all but the driest years even with actions such as increased downstream flow demands.

Winter would see both increased instream flows and increased reservoir water surface elevations, with Detroit seeing higher-than-average expected increases in inflow. The cumulative effects would reduce any additional winter-time flexibility after the fall drawdown at Green Peter by increasing inflows.

##### *4.2.1.6.2 Long Tom Subbasin*

Fern Ridge reservoir water surface elevations and downstream flows would moderately decrease during conservation season (spring to early fall) and increase during flood season (winter) from cumulative actions, including climate change and future population growth.

##### *4.2.1.6.3 McKenzie Subbasin*

Cougar reservoir would lose the minimal conservation season store water realized in Alternative 2B due to cumulative actions, including climate change and water withdraws, while Blue River would also see decreases from its increased stored water. Summer and fall flows downstream would decrease from their reduced levels and the variability in summer flows would continue to decrease.

During the winter, Cougar and Blue River would see both increased instream flows and increased reservoir water surface elevations. Although Cougar could mitigate some of this coming out of its fall drawdown, higher-than-average expected increases in inflow and lower storage volumes deeper in the reservoir mean that any such actions would likely be very limited in scope.

##### *4.2.1.6.4 Middle Fork of the Willamette Subbasin*

At Lookout Point and Hills Creek, conservation season storage would be decreased by cumulative actions, decreasing dry year flows when the reservoirs already reach their minimum water surface elevations to meet mainstem flow targets. The reservoirs would reach their minimum water surface elevations more often and earlier in the year to make up for the lack of stored water at Cougar reservoir. Fall Creek reservoir water surface elevations and releases would be lower.

Winter would see both increased instream flows and increased reservoir water surface elevations, particularly at Hills Creek due to higher-than-average expected increases in inflow.

##### *4.2.1.6.5 Coast Fork of the Willamette Subbasin*

Both Dorena and Cottage Grove reservoir water surface elevations would decrease during conservation season and would likely reach minimum conservation elevation in the driest years. Although Alternative 2B increases total storage, downstream flows would decrease in late fall when the reservoirs exhaust their stored water.

Winter would see both increased instream flows and increased reservoir water surface elevations due to climate change, but less so than in higher elevation basins.

##### *4.2.1.6.6 Mainstem Willamette River*

Instream flows would decrease during conservation season – from late spring through early fall – due to cumulative actions including climate change and water withdrawals. Although some additional stored water from the Santiam reservoirs would offset some of this reduction at Salem, the flow target at Albany would be missed more often during dry years. Summer flow variability would further decrease.

Winter flows would increase in the mainstem Willamette River in all except the driest years with climate change and population growth. The WVS operations may be able to increase average reservoir elevations during flood risk management operations to limit this increased flow. However, since most of the tributary area to the mainstem Willamette River is unregulated and increased inflows to the reservoirs would likely be coincident with the increased instream flows, the potential for winter-time reservoir management to offset increasing flows would be very limited in scope.

#### ***4.2.1.7 Alternative 3A – Operations-Focused Fish Passage Alternative***

The cumulative effects to hydrologic processes for Alterative 3a are divided by Willamette River subbasin based on the effects described at the top of this section. Overall, the cumulative effects to hydrologic processes would be expected to be major within the framework of Alternative 3A. Though Alternative 3A would alter the hydrology of the WVS to a greater extent than the cumulative actions during the PEIS analysis period, climate change would compound those changes across the Willamette River basin.

#### *4.2.1.7.1 Santiam Subbasin*

Detroit Reservoir would be even lower throughout conservation season due to cumulative actions, including climate change and increases in downstream flow demands. Typical instream flows would decrease, meeting flow targets in only the wettest years. Green Peter would also see its increased conservation storage diminish though from a higher level than at Detroit and likely has capacity to maintain similar downstream flows in the South Santiam River.

Winter would see both increased instream flows and increased reservoir water surface elevations, particularly at Detroit due to higher-than-average expected increases in inflow. The cumulative effects would reduce any additional winter-time flexibility after the fall drawdowns at both reservoirs by increasing inflows.

#### *4.2.1.7.2 Long Tom Subbasin*

Fern Ridge reservoir water surface elevations and downstream flows would moderately decrease during conservation season (spring to early fall) and increase during flood season (winter) from cumulative actions, including climate change and future population growth.

#### *4.2.1.7.3 McKenzie Subbasin*

Cougar reservoir would lose the minimal stored water realized during conservation season in Alternative 3A due to cumulative actions, including climate change and water withdraws. Blue River would also see decreases from its increased stored water, reaching minimum water surface elevation more often and earlier in the year. Summer and fall flows downstream would decrease from their reduced levels and the variability in summer flows would decrease.

During the winter, Cougar and Blue River would see both increased instream flows and increased reservoir water surface elevations, particularly at Cougar due to higher-than-average expected increases in inflow.

#### *4.2.1.7.4 Middle Fork of the Willamette Subbasin*

Conservation season storage would be reduced at Hills Creek and Lookout Point due to cumulative actions. Since Lookout Point comes out its spring drawdown in June, decreasing inflows will mean less storage in conservation season. The decreased downstream flows in Alternative 3A would be exacerbated and further decease flow variability in the subbasin. Fall Creek reservoir water surface elevations and releases would be lower.

Winter would see both increased instream flows and increased reservoir water surface elevations, particularly at Hills Creek due to higher-than-average expected increases in inflow.

#### *4.2.1.7.5 Coast Fork of the Willamette Subbasin*

Both Dorena and Cottage Grove reservoir water surface elevations would decrease during conservation season and would likely reach minimum conservation elevation in dry years.

Although Alternative 3A increases peak storage, the reservoirs would have to release maintain flows and see less conservation season inflow due to cumulative actions.

Winter would see both increased instream flows and increased reservoir water surface elevations due to climate change, but less so than in higher elevation basins.

##### *4.2.1.7.6 Mainstem Willamette River*

Instream flows would decrease during conservation season – from late spring through early fall – from already minimum levels due to cumulative actions including climate change and water withdrawals. The Albany flow target would rarely, if ever, be met from July through September. Additional flow from Green Peter would help meet the Salem flow target more regularly than the Albany flow target. However, the limited and decreasing storage at Detroit would mean that long summer and fall periods below the Salem flow target would be inevitable.

Winter flows would increase in the mainstem Willamette River in all except the driest years with climate change and population growth. The WVS operations may be able to increase average reservoir elevations during flood risk management operations to limit this increased flow. However, since most of the tributary area to the mainstem Willamette River is unregulated and increased inflows to the reservoirs would likely be coincident with the increased instream flows, the potential for winter-time reservoir management to offset increasing flows would be very limited in scope.

#### ***4.2.1.8 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)***

The cumulative effects to hydrologic processes for Alterative 3b are divided by Willamette River subbasin based on the effects described at the top of this section. Overall, the cumulative effects to hydrologic processes would be expected to be major within the framework of Alternative 3B. Though Alternative 3B would alter the hydrology of the WVS to a greater extent than the cumulative actions during the PEIS analysis period, climate change would compound those changes across the Willamette River basin.

##### *4.2.1.8.1 Santiam Subbasin*

Cumulative actions, including climate change and increases in downstream flow demands, would offset some water surface elevation increases at Detroit reservoir throughout conservation season. However, typical instream flows directly downstream of the dam would likely remain similar due to the remaining storage. Green Peter would not likely fill to minimum conservation pool in the summer and Foster would exhaust its smaller storage capacity more often and earlier in the year. Flow targets downstream of Foster would only be met in the wettest years, with dry years only passing the inflow from the South Santiam reservoirs for many months.

Winter would see both increased instream flows and increased reservoir water surface elevations, particularly at Detroit due to higher-than-average expected increases in inflow. The cumulative effects would reduce any additional winter-time flexibility after the fall drawdowns at both reservoirs by increasing inflows.

##### *4.2.1.8.2 Long Tom Subbasin*

Fern Ridge reservoir water surface elevations and downstream flows would moderately decrease during conservation season (spring to early fall) and increase during flood season (winter) from cumulative actions, including climate change and future population growth.

##### *4.2.1.8.3 McKenzie Subbasin*

Cougar reservoir would lose the minimal stored water realized during conservation season in Alternative 3B due to cumulative actions, including climate change and water withdraws, while Blue River would also see decreases from its increased stored water. Summer and fall flows downstream would decrease from their reduced levels and the variability in summer flows would continue to decrease.

During the winter, Cougar and Blue River would see both increased instream flows and increased reservoir water surface elevations. Although Cougar could mitigate some of this coming out of its fall drawdown, higher-than-average expected increases in inflow and lower storage volumes deeper in the reservoir mean that any such actions would likely be very limited in scope.

##### *4.2.1.8.4 Middle Fork of the Willamette Subbasin*

Conservation season storage would be reduced at Hills Creek and Lookout Point due to cumulative actions. Since the Hills Creek average basin elevation is higher, decreasing inflows would occur earlier in the year, likely reducing the already low conservation storage in Alternative 3B. Since Lookout Point reaches its minimum water surface elevation only in the driest years, it would be able to supplement downstream flows somewhat. Fall Creek reservoir water surface elevations and releases would be lower.

Winter would see both increased instream flows and increased reservoir water surface elevations, particularly at Hills Creek due to higher-than-average expected increases in inflow.

##### *4.2.1.8.5 Coast Fork of the Willamette Subbasin*

Both Dorena and Cottage Grove reservoir water surface elevations would decrease during conservation season and would likely reach minimum conservation elevation in the driest years. Although Alternative 2B increases total storage, downstream flows would decrease in late fall when the reservoirs exhaust their stored water.

Winter would see both increased instream flows and increased reservoir water surface elevations due to climate change, but less so than in higher elevation basins.

##### *4.2.1.8.6 Mainstem Willamette River*

Instream flows would decrease during conservation season – from late spring through early fall – due to cumulative actions including climate change and water withdrawals. The flow target at Albany would be missed more often and for longer periods during dry years. The Salem flow target would be missed more often during the same periods as low flow at Albany.

Winter flows would increase in the mainstem Willamette River in all except the driest years with climate change and population growth. The WVS operations may be able to increase average reservoir elevations during flood risk management operations to limit this increased flow. However, since most of the tributary area to the mainstem Willamette River is unregulated and increased inflows to the reservoirs would likely be coincident with the increased instream flows, the potential for winter-time reservoir management to offset increasing flows would be very limited in scope.

#### ***4.2.1.9 Alternative 4 – Structures-Based Fish Passage Alternative***

The cumulative effects to hydrologic processes for Alterative 4 are divided by Willamette River subbasin based on the effects described at the top of this section. Overall, the cumulative effects to hydrologic processes would be expected to be moderate within the framework of Alternative 4. During the PEIS analysis period, Alternative 4 would alter the hydrology of the WVS to a greater extent than the cumulative actions, though climate change and water withdrawals would measurably change certain aspects of the WVS operations.

##### *4.2.1.9.1 Santiam Subbasin*

The cumulative actions would decrease reservoir water surface elevations at Detroit and Green Peter in the conservation season. Since Alternative 4 increases total storage at Detroit, downstream flows would remain similar even with actions such as increased downstream flow demands. Foster would occasionally miss its flow target due to Green Peter exhausting its storage in the driest years.

Winter would see both increased instream flows and increased reservoir water surface elevations, particularly at Detroit due to higher-than-average expected increases in inflow.

##### *4.2.1.9.2 Long Tom Subbasin*

Fern Ridge reservoir water surface elevations and downstream flows would moderately decrease during conservation season (spring to early fall) and increase during flood season (winter) from cumulative actions, including climate change and future population growth.

##### *4.2.1.9.3 McKenzie Subbasin*

Predicted conservation season reservoir water surface elevation increases at Cougar and Blue River would be offset by cumulative actions, including climate change and water withdraws. Flow releases would also decrease in dry years but remain relatively stable in average years.

Winter would see both increased instream flows and increased reservoir water surface elevations, particularly at Cougar due to higher-than-average expected increases in inflow.

##### *4.2.1.9.4 Middle Fork of the Willamette Subbasin*

At Lookout Point and Hills Creek, increased conservation season storage would be decreased by cumulative actions, decreasing dry year flows when the reservoirs already reach their minimum water surface elevations to meet mainstem flow targets. Fall Creek reservoir water surface elevations and releases would be lower.

Winter would see both increased instream flows and increased reservoir water surface elevations, particularly at Hills Creek due to higher-than-average expected increases in inflow.

##### *4.2.1.9.5 Coast Fork of the Willamette Subbasin*

Both Dorena and Cottage Grove reservoir water surface elevations would decrease during conservation season. Since Alternative 4 increases total storage, downstream flows would remain similar.

Winter would see both increased instream flows and increased reservoir water surface elevations due to climate change, but less so than in higher elevation basins.

##### *4.2.1.9.6 Mainstem Willamette River*

Instream flows would decrease during conservation season – from late spring through early fall – due to cumulative actions including climate change and water withdrawals. Although the addition of stored water from the WVS reservoirs would offset some of this reduction, the flow targets at Albany and Salem would be missed more often during the summer and fall.

Winter flows would increase in the mainstem Willamette River in all except the driest years with climate change and population growth. The WVS operations may be able to increase average reservoir elevations during flood risk management operations to limit this increased flow. However, since most of the tributary area to the mainstem Willamette River is unregulated and increased inflows to the reservoirs would likely be coincident with the increased instream flows, the potential for winter-time reservoir management to offset increasing flows would be very limited in scope.

#### ***4.2.1.10 Alternative 5 – Revised Integrated Water Management Flexibility and ESA-Listed Fish Alternative***

The cumulative effects to hydrologic processes for Alternative 5 are divided by Willamette River subbasin based on the effects described at the top of this section. Overall, the cumulative effects to hydrologic processes would be expected to be moderate with the framework of Alternative 5. During the PEIS analysis period, Alternative 5 would alter the hydrology of the WVS to a greater extent than the cumulative actions, though climate change and water withdrawals would measurably change certain aspects of the WVS operations.

#### *4.2.1.10.1 Santiam Subbasin*

The cumulative actions would decrease reservoir elevations at Detroit and Green Peter in the conservation season. Since Alternative 5 increases total storage as compared the NAA, downstream flows would likely remain similar for all but the driest years even with actions such as increased downstream flow demands.

Winter would see both increased instream flows and increased reservoir water surface elevations, with Detroit seeing higher-than-average expected increases in inflow. The cumulative effects would reduce any additional winter-time flexibility after the fall drawdown at Green Peter by increasing inflows.

#### *4.2.1.10.2 Long Tom Subbasin*

Fern Ridge reservoir water surface elevations and downstream flows would moderately decrease during conservation season (spring to early fall) and increase during flood season (winter) from cumulative actions, including climate change and future population growth.

#### *4.2.1.10.3 McKenzie Subbasin*

Cougar reservoir would lose the minimal conservation season store water realized in Alternative 5 due to cumulative actions, including climate change and water withdraws, while Blue River would also see decreases from its increased stored water. Summer and fall flows downstream would decrease from their reduced levels and the variability in summer flows would continue to decrease.

During the winter, Cougar and Blue River would see both increased instream flows and increased reservoir water surface elevations. Although Cougar could mitigate some of this coming out of its fall drawdown, higher-than-average expected increases in inflow and lower storage volumes deeper in the reservoir mean that any such actions would likely be very limited in scope.

#### *4.2.1.10.4 Middle Fork of the Willamette Subbasin*

At Lookout Point and Hills Creek, conservation season storage would be decreased by cumulative actions, decreasing dry year flows when the reservoirs already reach their minimum water surface elevations to meet mainstem flow targets. The reservoirs would reach their minimum water surface elevations more often and earlier in the year to make up for the lack of stored water at Cougar reservoir. Fall Creek reservoir water surface elevations and releases would be lower.

Winter would see both increased instream flows and increased reservoir water surface elevations, particularly at Hills Creek due to higher-than-average expected increases in inflow.

#### *4.2.1.10.5 Coast Fork of the Willamette Subbasin*

Both Dorena and Cottage Grove reservoir water surface elevations would decrease during conservation season and would likely reach minimum conservation elevation in the driest years. Although Alternative 5 increases total storage, downstream flows would decrease in late fall when the reservoirs exhaust their stored water.

Winter would see both increased instream flows and increased reservoir water surface elevations due to climate change, but less so than in higher elevation basins.

#### *4.2.1.10.6 Mainstem Willamette River*

Instream flows would decrease during conservation season – from late spring through early fall – due to cumulative actions including climate change and water withdrawals. Although some additional stored water from the Santiam reservoirs would limit the frequency of missing the flow target at Salem, the flow target at Albany would be missed more often and for longer periods during dry years. Summer flow variability would further decrease.

Winter flows would increase in the mainstem Willamette River in all except the driest years with climate change and population growth. The WVS operations may be able to increase average reservoir elevations during flood risk management operations to limit this increased flow. However, since most of the tributary area to the mainstem Willamette River is unregulated and increased inflows to the reservoirs would likely be coincident with the increased instream flows, the potential for winter-time reservoir management to offset increasing flows would be very limited in scope.

## 4.3 RIVER MECHANICS AND GEOMORPHOLOGY

### 4.3.1 Cumulative Effects Analysis Methodology for River Mechanics and Geomorphology

This analysis is a qualitative assessment of the anticipated trends to River Mechanics and Geomorphology resource.

#### *4.3.1.1 Cumulative Actions Applicable to River Mechanics and Geomorphology*

Past, present, and RFFAs that, when considered together with the Proposed Action and alternatives, would have cumulative effects on River Mechanics and Geomorphology include:

- WVS and Other Dams and Reservoirs in the WRB: construction and past operations and maintenance (see section 4.2.1.1) and ongoing operations and maintenance (see section 4.2.2)
- WRB Population Growth and Development: altered land use within to the Willamette River basin (see section 4.2.1.2)
- RFFA 1: Future population growth and accompanying urban, industrial, and commercial development
- RFFA 2: Future agricultural development
- RFFA 3: Water withdrawals for municipal, industrial, and agricultural uses
- RFFA 5: Federal and state wildlife and lands management
- RFFA 7: Tribal, state, and local fish and wildlife improvement
- RFFA 9: Climate change
- RFFA 10: Mining operations
- RFFA 11: Timber and logging industry operations

Some of the other RFFAs discussed in Section 4.2.3 would not change sediment processes or geomorphology of the Willamette Basin or only negligibly alter the WVS dam and reservoir operations and as such would not have a cumulative effect on river mechanics and geomorphology. These include:

- RFFA 4: Decarbonizing the energy sector with renewable energy sources. There is minimal variation in total flow due to outlet choice, such as whether to run the WVS dam's hydroelectric turbines.
- RFFA 6: Fishery management and killer whales. The flow targets in the WVS are specific to the river reaches and habitat where they occur. They are not variable based on Pacific Ocean salmon returns.
- RFFA 8: Invasive species management. Does not affect flow or regulation decisions for the WVS dams.

Therefore, these RFFAs are dismissed from further analysis.

### 4.3.2 Cumulative Effects to River Mechanics and Geomorphology by Alternative

The WVS dams and reservoirs are currently authorized for flood control, hydropower, pollution abatement, fish and wildlife conservation, recreation, irrigation, municipal and industrial water supply, and water quality. Existing river processes and geomorphology are changed from the natural condition by construction and operation of the WVS dams and reservoirs, public and private bank protection and river training, land use both urban and rural, resource extraction, transportation infrastructure development, river navigation both recreational and commercial, and past visions of flood risk management including large scale removal of large wood. The cumulative effect of these large scale past actions is conversion of river to inland lakes in the form of reservoirs and a simplified river form in the regulated river reaches that are less dynamic and experience less connection with their historical floodplain. Cumulative effects described in this section are relative to the existing condition in order to highlight differences between alternatives. Other dams and reservoirs within the WRB are more numerous (estimated to be 247 additional non-USACE dams) but generally much smaller in height and volume. Few of these projects have flood control operations or storage capacity and do not attempt to reduce peak flows that are drivers for morphological activity. The primary driver for peak flow reduction in the WVS remains the USACE WVS flood control projects. The non-USACE dams to impound sediment but likely offset increased sediment supply from development and land management. The cumulative actions would create adverse, additive, and minor to moderate effects to river mechanics and geomorphology.

Future population growth and accompanying urban, industrial, and commercial development (RFFA 1) occurring in historical floodplains would lock the landscape into a developed condition and encourage river and bank stabilization to ensure property protection. Floodplain fill, likely to the 100-year FEMA base flood elevation, and subsequent floodplain disconnection from the river would simplify the river form and future morphological processes. Additionally, sediment supplied to the river from the converted lands would change in nature from crop or pasture fines and intermittent coarser sediments from bank erosion to predominately urbanized and industrial fines. Potential for increased deep draft port traffic in the lower Willamette may result in increased dredging to maintain port and navigation channel depth. Hydrologic changes due to RFFA 1 actions are negligible to subreach scale sediment processes. Given extents of existing development in the WVS and limitations put on development through Oregon's urban growth boundary laws, the cumulative actions would create adverse, additive, and minor effects to river mechanics and geomorphology.

Future agricultural development (RFFA 2) occurring in historical floodplains would encourage stabilization of the river and riparian landscape into a developed condition and encourage bank stabilization to ensure property protection. Outside of the urban growth boundaries, floodplain development would likely be in the form of larger ranchettes or properties that take advantage of the river and riparian amenities. Floodplain fill, likely to the 100-year FEMA base flood elevation, and flood water management through the development of training berms or levees would further disconnect the river from the floodplain and simplify the river form and future morphological processes. Bank protection would limit re-mobilization of stored coarse sediments and encourage further vertical river incision. The cumulative actions would create adverse, additive, and minor effects to river mechanics and geomorphology.

Water withdrawals for municipal, industrial, and agricultural uses (RFFA 3) would have the effect of either decreasing reservoir water surface elevation, decreasing instream flows, or a combination of both. Decreased water surface elevation would increase reservoir bank exposure and potential for scour and suspension of fine sediments from the reservoir banks. The cumulative actions would create adverse, additive, and minor effects to sediment supply.

Federal and state wildlife and lands management (RFFA 5) and timber and logging industry operations (RFFA 11) happen throughout the regulated and unregulated portions of the watershed and are conservation focused or expected to occur at similar rates to the recent past. Rates of surface erosion and sediment supply due to land management are expected to remain unchanged. Increased awareness of the value of riparian corridors and preservation of future large wood sources during resource extraction would improve river and riparian complexity. The cumulative actions would be additive and minor effects to sediment supply and geomorphology.

Tribal, state, and local fish and wildlife improvement (RFFA 7) would include river and floodplain restoration actions and potentially environmental flows to inundate habitats and mobilize bed sediments. Restoration actions would directly and locally modify river and riparian form and function; however, the scale of most restoration actions limit the river mechanics and geomorphology impacts to the local project area. Environmental flows have been performed historically in the Willamette system but have been limited in magnitude to non-damaging peak flows similar to smaller regulated flood events. The cumulative actions would create beneficial, additive, and minor effects to overall system river mechanics and geomorphology.

Climate change (RFFA 9) would increase winter inflows and sediment supply to the Willamette basin, both upstream and downstream of the WVS dams and reservoirs. Additionally, there is causal relationship between wildfires and increased sediment supply. Expected increases in very high fire danger days and associated increases in forest fire acreages are expected to increase basin sediment yields due to climate change. Reservoirs act as sediment traps and would partially mitigate increases in sediment supply in regulated reaches by trapping additional sediment. Additionally, climate change generally decreases conservation season flows and therefore conservations season reservoir stages (Section 4.3). This could increase bank exposure, decrease reservoir storage and increase fine grained suspended sediment concentrations in the reservoirs and sediment releases downstream. As climate change does not increase operational range, but only stages within the operational rage, this conservation season change is expected to be negligible to minor. See the climate change sections in section 3.3 for more information. Effects would be additive with the other RFFAs within their respective seasons.

Mining operations (RFFA 10) would include gravel and sand extraction from river adjacent floodplain pits. Existing and proposed new pits or expansions are subject to current environmental protection laws and are typically separated from the river by levees or natural high land limiting sediment releases to the river. Levees and associated river training and bank protection to enforce the isolation in turn simplify morphological processes in the adjacent river, disconnect the river the floodplain and permanently modify the landscape by extraction. The cumulative actions would create adverse, additive, and minor effects to sediment supply and morphology.

In general, the combination of the RFFAs with an effect on river mechanics and geomorphology minorly changes the current trajectory of the basin. Restoration and land use that view the river as an amenity may partially offset future development and resource extraction demands in the continued simplification of the river and river processes. Many of the RFFAs would have varying but localized minor effects to river mechanics and geomorphology. Of the RFFAs, climate change and its associated hydrological and sediment supply changes, particularly in unregulated tributaries and regulated reaches with large unregulated contributing areas, has the most potential to affect large scale changes with increased sediment supply, winter flows and associated morphologic activity.

General trends described in this section apply to all subbasins within the WVB. It is unknown to what magnitude climate change, increased development, and other cumulative actions may impact future trends in sediment processes. Many of the RFFAs offset each other to some degree for the river mechanics and geomorphology resource at the subbasin scale, for example development may seek to harden and bank from erosion while restoration may seek to modify or remove an existing revetment. Location, extents, and timing of these actions are unknown. Climate change and associated winter flow and sediment supply increases are likely the largest additive driver for cumulative changes to WVS river mechanics and geomorphology. To that end, and to prevent undue repetition of general trends in alternative analysis, general trends apply to all alternatives and subbasins with impacts being long-term and basin-wide by default unless otherwise noted.

#### *4.3.2.1 No Action Alternative*

Combined with the effects of the RFFAs including climate change, there would likely be additional effects to sediment processes (changes from existing condition) under the No Acton Alternative. As discussed in section 3.3.3.1, the effects of the No Action Alternative do not appreciably change the geomorphology and sediment processes, or the closely related hydrology and hydraulics, of the WVS from the existing conditions. Overall cumulative effects would be additive, with negligible to minor increases, in the effect and long-term to the WVB as affected by cumulative actions, which are largely influenced by anticipated climate change and continued development. For example, a minor increase in sediment supply to a reach due to changes in operation may be a minor to moderate increase when cumulative effects are considered. A negligible effect may remain negligible or pass the threshold into a minor effect. Major effects would remain major. Effects as discussed in section 3.3.3.1 of the NAA.

#### *4.3.2.2 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

RFFAs with the potential to contribute to cumulative effects to geomorphology and sediment transport are described in section 4.3.1. General trends described in this section apply to all subbasins within the WSV. Overall cumulative effects would be additive, with negligible to minor increases in the effect, and long-term to the WVB as affected by cumulative actions, which are largely influenced by anticipated climate change and continued development. For example, a minor increase in sediment supply to a reach due to changes in operation may be a minor to moderate increase when cumulative effects are considered. A negligible effect may remain negligible or pass the threshold into a minor effect. Major effects would remain major. The direct/indirect effects of Alternative 1 compared to the No Action Alternative are summarized in Table 3.3-2.

##### *4.3.2.2.1 Santiam Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Santiam Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.2). Higher-than-average winter flows in Detroit and associated higher sediment inflows would be offset by higher reservoir water surface elevations resulting in negligible change in sediment releases from the reservoir. A higher-than-average increase in depositional rates within the reservoir may occur.

##### *4.3.2.2.2 Long Tom Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Long Tom Subbasin, both upstream and downstream of the WVS dams and reservoirs, and reservoirs as well as a decrease in conservation season reservoir stages (Section 4.3.3.2).

##### *4.3.2.2.3 McKenzie Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the McKenzie Subbasin, both upstream and downstream of the WVS dams and reservoirs (Section 4.3.3.2). Higher-than-average winter flows in Cougar and associated higher sediment inflows would be offset by higher reservoir water surface elevations resulting in negligible change in sediment releases from the reservoir. A higher-than-average increase in depositional rates within the reservoir may occur.

##### *4.3.2.2.4 Middle Fork of the Willamette Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Middle Fork of the Willamette Subbasin, both upstream and downstream of the WVS dams and reservoirs (Section 4.3.3.2). Higher-than-average winter flows in Hills Creek and associated higher sediment inflows would be offset by higher reservoir water surface elevations resulting in negligible change in sediment releases from the reservoir. A higher-than-average increase in depositional rates within the reservoir may occur.

##### *4.3.2.2.5 Coast Fork of the Willamette Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Coast Fork of the Willamette Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.2).

##### *4.3.2.2.6 Mainstem Willamette River*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Mainstem Willamette River. The source the increased sediment is likely headwaters making uncertain the magnitude in increase transported to the mainstem river. The mainstem Willamette is the subbasin most likely to see development (RFFAs 1 and 2) and restoration (RFFA 7) offsets that have uncertainty in location and magnitude. It is unknown to what magnitude cumulative actions would impact future sediment processes.

#### ***4.3.2.3 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative***

RFFAs with the potential to contribute to cumulative effects to geomorphology and sediment transport are described in section 4.3.1. General trends described in this section 4.3.1apply to all subbasins within the WSV. Overall cumulative effects would be additive, with negligible to minor increases in the effect, and long-term to the WVB as affected by cumulative actions, which are largely influenced by anticipated climate change and continued development. For example, a minor increase in sediment supply to a reach due to changes in operation may be a minor to moderate increase when cumulative effects are considered. A negligible effect may remain negligible or pass the threshold into a minor effect. Major effects would remain major. The direct/indirect effects of Alternative 2A compared to the No Action Alternative are summarized in Table 3.3-3.

##### *4.3.2.3.1 Santiam Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Santiam Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.3). Higher-than-average winter flows in Detroit and associated higher sediment inflows would be offset by higher reservoir water surface elevations resulting in negligible change in sediment releases from the reservoir. A higher-than-average increase in depositional rates within the reservoir may occur.

##### *4.3.2.3.2 Long Tom Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Long Tom Subbasin, both upstream and downstream of the WVS dams and reservoirs, and reservoirs as well as a decrease in conservation season reservoir stages (Section 4.3.3.3).

##### *4.3.2.3.3 McKenzie Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the McKenzie Subbasin, both upstream and downstream of the WVS dams and reservoirs (Section 4.3.3.3). Higher-than-average winter flows in Cougar and associated higher sediment inflows would be offset by higher reservoir water surface elevations resulting in negligible change in sediment releases from the reservoir. A higher-than-average increase in depositional rates within the reservoir may occur.

##### *4.3.2.3.4 Middle Fork of the Willamette Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Middle Fork of the Willamette Subbasin, both upstream and downstream of the WVS dams and reservoirs (Section 4.3.3.3). Higher-than-average winter flows in Hills Creek and associated higher sediment inflows would be offset by higher reservoir water surface elevations resulting in negligible change in sediment releases from the reservoir. A higher-than-average increase in depositional rates within the reservoir may occur.

##### *4.3.2.3.5 Coast Fork of the Willamette Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Coast Fork of the Willamette Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.3).

##### *4.3.2.3.6 Mainstem Willamette River*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Mainstem Willamette River. The source the increased sediment is likely headwaters making uncertain the magnitude in increase transported to the mainstem river. The mainstem Willamette is the subbasin most likely to see development (RFFAs 1 and 2) and restoration (RFFA 7) offsets that have uncertainty in location and magnitude. It is unknown to what magnitude cumulative actions of would impact future sediment processes.

#### ***4.3.2.4 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative***

RFFAs with the potential to contribute to cumulative effects to geomorphology and sediment transport are described in section 4.3.1. General trends described in this section apply to all subbasins within the WSV. Overall cumulative effects would be additive, with negligible to minor increases in the effect, and long-term to the WVB as affected by cumulative actions, which are largely influenced by anticipated climate change and continued development. For example, a minor increase in sediment supply to a reach due to changes in operation may be a minor to moderate increase when cumulative effects are considered. A negligible effect may remain negligible or pass the threshold into a minor effect. Major effects would remain major. The direct/indirect effects of Alternative 2B compared to the No Action Alternative are summarized in Table 3.3-4.

##### *4.3.2.4.1 Santiam Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Santiam Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.4). Higher-than-average winter flows in Detroit and Green Peter associated higher sediment inflows would be offset by higher reservoir water surface elevations resulting in negligible change in sediment releases from the reservoirs. A higher-than-average increase in depositional rates within the reservoirs may occur.

##### *4.3.2.4.2 Long Tom Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Long Tom Subbasin, both upstream and downstream of the WVS dams and reservoirs, and reservoirs as well as a decrease in conservation season reservoir stages (Section 4.3.3.4).

##### *4.3.2.4.3 McKenzie Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the McKenzie Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.4).

##### *4.3.2.4.4 Middle Fork of the Willamette Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Middle Fork of the Willamette Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.4). Higher-than-average winter flows into Hills Creek and associated higher sediment inflows would be offset by higher reservoir water surface elevations resulting in negligible change in sediment releases from the reservoir. A higher-than-average increase in depositional rates within the reservoir may occur.

##### *4.3.2.4.5 Coast Fork of the Willamette Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Coast Fork of the Willamette Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.4).

##### *4.3.2.4.6 Mainstem Willamette River*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Mainstem Willamette River. The source the increased sediment is likely headwaters making uncertain the magnitude in increase transported to the mainstem river. The mainstem Willamette is the subbasin most likely to see development (RFFAs 1 and 2) and restoration (RFFA 7) offsets that have uncertainty in location and magnitude. It is unknown to what magnitude cumulative actions of would impact future sediment processes.

#### ***4.3.2.5 Alternative 3A – Operations-Focused Fish Passage Alternative***

RFFAs with the potential to contribute to cumulative effects to geomorphology and sediment transport are described in section 4.3.1. General trends described in this section apply to all subbasins within the WSV. Overall cumulative effects would be additive, with negligible to minor increases in the effect, and long-term to the WVB as affected by cumulative actions, which are largely influenced by anticipated climate change and continued development. For example, a minor increase in sediment supply to a reach due to changes in operation may be a minor to moderate increase when cumulative effects are considered. A negligible effect may remain negligible or pass the threshold into a minor effect. Major effects would remain major. The direct/indirect effects of Alternative 3A compared to the No Action Alternative are summarized in Table 3.3-5.

##### *4.3.2.5.1 Santiam Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Santiam Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.5). Higher-than-average winter flows in Detroit associated higher sediment inflows would be offset by higher reservoir water surface elevations resulting in negligible change in sediment releases from the reservoir. A higher-than-average increase in depositional rates within the reservoirs may occur. Lower than average pool stages in Detroit reservoir during the conservation season increase the potential for fine grained sediment suspension in the pool and downstream sediment releases to Big Cliff reservoir.

##### *4.3.2.5.2 Long Tom Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Long Tom Subbasin, both upstream and downstream of the WVS dams and reservoirs, and reservoirs as well as a decrease in conservation season reservoir stages (Section 4.3.3.5).

#### *4.3.2.5.3 McKenzie Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the McKenzie Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.5). Higher-than-average winter flows in Cougar and associated higher sediment inflows would be offset by higher reservoir water surface elevations resulting in negligible change in sediment releases from the reservoir. A higher-than-average increase in depositional rates within the reservoir may occur.

#### *4.3.2.5.4 Middle Fork of the Willamette Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Middle Fork of the Willamette Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.5). Higher-than-average winter flows in Hills Creek and associated higher sediment inflows would be offset by higher reservoir water surface elevations resulting in negligible change in sediment releases from the reservoir. A higher-than-average increase in depositional rates within the reservoir may occur.

#### *4.3.2.5.5 Coast Fork of the Willamette Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Coast Fork of the Willamette Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.5).

#### *4.3.2.5.6 Mainstem Willamette River*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Mainstem Willamette River. The source the increased sediment is likely headwaters making uncertain the magnitude in increase transported to the mainstem river. The mainstem Willamette is the subbasin most likely to see development (RFFAs 1 and 2) and restoration (RFFA 7) offsets that have uncertainty in location and magnitude. It is unknown to what magnitude cumulative actions of would impact future sediment processes.

### *4.3.2.6 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)*

RFFAs with the potential to contribute to cumulative effects to geomorphology and sediment transport are described in section 4.3.1. General trends described in this section apply to all subbasins within the WSV. Overall cumulative effects would be additive, with negligible to minor increases in the effect, and long-term to the WVB as affected by cumulative actions, which are largely influenced by anticipated climate change and continued development. For example, a minor increase in sediment supply to a reach due to changes in operation may be a minor to moderate increase when cumulative effects are considered. A negligible effect may remain negligible or pass the threshold into a minor effect. Major effects would remain major. The direct/indirect effects of Alternative 3B compared to the No Action Alternative are summarized in Table 3.3-6.

###### *4.3.2.6.1 Santiam Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Santiam Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.6). Higher-than-average winter flows in Detroit associated higher sediment inflows would be offset by higher reservoir water surface elevations resulting in negligible change in sediment releases from the reservoir. A higher-than-average increase in depositional rates within the reservoirs may occur.

###### *4.3.2.6.2 Long Tom Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Long Tom Subbasin, both upstream and downstream of the WVS dams and reservoirs, and reservoirs as well as a decrease in conservation season reservoir stages (Section 4.3.3.6).

###### *4.3.2.6.3 McKenzie Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the McKenzie Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.6).

###### *4.3.2.6.4 Middle Fork of the Willamette Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Middle Fork of the Willamette Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.6). Higher-than-average winter flows in Hills Creek and associated higher sediment inflows would be offset by higher reservoir water surface elevations resulting in negligible change in sediment releases from the reservoir. A higher-than-average increase in depositional rates within the reservoir may occur.

###### *4.3.2.6.5 Coast Fork of the Willamette Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Coast Fork of the Willamette Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.6).

##### *4.3.2.6.6 Mainstem Willamette River*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Mainstem Willamette River. The source the increased sediment is likely headwaters making uncertain the magnitude in increase transported to the mainstem river. The mainstem Willamette is the subbasin most likely to see development (RFFAs 1 and 2) and restoration (RFFA 7) offsets that have uncertainty in location and magnitude. It is unknown to what magnitude cumulative actions of would impact future sediment processes.

#### *4.3.2.7 Alternative 4 – Structures-Based Fish Passage Alternative*

RFFAs with the potential to contribute to cumulative effects to geomorphology and sediment transport are described in section 4.3.1. General trends described in this section apply to all subbasins within the WSV. Overall cumulative effects would be additive, with negligible to minor increases in the effect, and long-term to the WVB as affected by cumulative actions, which are largely influenced by anticipated climate change and continued development. For example, a minor increase in sediment supply to a reach due to changes in operation may be a minor to moderate increase when cumulative effects are considered. A negligible effect may remain negligible or pass the threshold into a minor effect. Major effects would remain major. The direct/indirect effects of Alternative 4 compared to the No Action Alternative are summarized in Table 3.3-7.

##### *4.3.2.7.1 Santiam Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Santiam Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.7). Higher-than-average winter flows in Detroit and Green Peter associated higher sediment inflows would be offset by higher reservoir water surface elevations resulting in negligible change in sediment releases from the reservoirs. A higher-than-average increase in depositional rates within the reservoirs may occur.

##### *4.3.2.7.2 Long Tom Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Long Tom Subbasin, both upstream and downstream of the WVS dams and reservoirs, and reservoirs as well as a decrease in conservation season reservoir stages (Section 4.3.3.7).

##### *4.3.2.7.3 McKenzie Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the McKenzie Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.7).

##### *4.3.2.7.4 Middle Fork of the Willamette Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Middle Fork of the Willamette Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.7). Higher-than-average winter flows into Hills Creek and associated higher sediment inflows would be offset by higher reservoir water surface elevations resulting in negligible change in sediment releases from the reservoir. A higher-than-average increase in depositional rates within the reservoir may occur.

##### *4.3.2.7.5 Coast Fork of the Willamette Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Coast Fork of the Willamette Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.7).

##### *4.3.2.7.6 Mainstem Willamette River*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Mainstem Willamette River. The source the increased sediment is likely headwaters making uncertain the magnitude in increase transported to the mainstem river. The mainstem Willamette is the subbasin most likely to see development (RFFAs 1 and 2) and restoration (RFFA 7) offsets that have uncertainty in location and magnitude. It is unknown to what magnitude cumulative actions of would impact future sediment processes.

#### ***4.3.2.8 Alternative 5***

RFFAs with the potential to contribute to cumulative effects to geomorphology and sediment transport are described in section 4.3.1. General trends described in this section apply to all subbasins within the WVS. Overall cumulative effects would be additive, with negligible to minor increases in the effect, and long-term to the WVB as affected by cumulative actions, which are largely influenced by anticipated climate change and continued development. For example, a minor increase in sediment supply to a reach due to changes in operation may be a minor to moderate increase when cumulative effects are considered. A negligible effect may remain negligible or pass the threshold into a minor effect. Major effects would remain major. The direct/indirect effects of Alternative 5 compared to the No Action Alternative are summarized in Table 3.3-8.

##### *4.3.2.8.1 Santiam Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Santiam Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.4). Higher-than-average winter flows in Detroit and Green Peter associated higher sediment inflows would be offset by higher reservoir water surface elevations resulting in negligible change in sediment releases from the reservoirs. A higher-than-average increase in depositional rates within the reservoirs may occur.

##### *4.3.2.8.2 Long Tom Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Long Tom Subbasin, both upstream and downstream of the WVS dams and reservoirs, and reservoirs as well as a decrease in conservation season reservoir stages (Section 4.3.3.4).

##### *4.3.2.8.3 McKenzie Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the McKenzie Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.4).

##### *4.3.2.8.4 Middle Fork of the Willamette Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Middle Fork of the Willamette Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.4). Higher-than-average winter flows into Hills Creek and associated higher sediment inflows would be offset by higher reservoir water surface elevations resulting in negligible change in sediment releases from the reservoir. A higher-than-average increase in depositional rates within the reservoir may occur.

##### *4.3.2.8.5 Coast Fork of the Willamette Subbasin*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Coast Fork of the Willamette Subbasin, both upstream and downstream of the WVS dams and reservoirs, as well as a decrease in conservation season reservoir stages (Section 4.3.3.4).

##### *4.3.2.8.6 Mainstem Willamette River*

The anticipated trends of cumulative actions would see an increase in winter inflows and sediment supply to the Mainstem Willamette River. The source the increased sediment is likely headwaters making uncertain the magnitude in increase transported to the mainstem river. The mainstem Willamette is the subbasin most likely to see development (RFFAs 1 and 2) and restoration (RFFA 7) offsets that have uncertainty in location and magnitude. It is unknown to what magnitude cumulative actions of would impact future sediment processes.

## 4.4 GEOLOGY AND SOILS

### 4.4.1 Cumulative Effects Analysis Methodology for Geology and Soils

The cumulative effects analysis for Geology and Soils is qualitative and examines effects within the WVB over the period of analysis. This analysis focuses on anticipated impacts to landslides from hydrologic process trends based upon the relevant cumulative actions discussed in the scenario.

#### *4.4.1.1 Cumulative Actions Applicable to Geology and Soils*

Past, present, and RFFAs that, when considered together with the Proposed Action and alternatives, would have cumulative effects on Geology and Soils, include:

- WVS and Other Dams and Reservoirs in the WRB: construction and past operations and maintenance (see section 4.1.2.1.1)
- WVS Dams and Reservoirs: ongoing operations and maintenance (see section 4.1.2.2)
- RFFA 3: Water withdrawals for municipal, industrial, and agricultural uses
- RFFA 8: Tribal, state, and local fish and wildlife improvement
- RFFA 10: Climate change
- RFFA 11: Mining operations
- RFFA 12: Timber and logging industry operations.

Effects on soils due to past and future factors that impact land use (WRB Population Growth and Development and RFFA 1 and 2) are generally better described in terms of geomorphology (section 4.4). Some of the other RFFAs discussed in Section 4.2.3 would not occur at or in close proximity to the WVS dams and reservoirs and as such would not have a cumulative effect on geology and soils within the area of interest. These include:

- WRB Population Growth and Development: altered land use within to the Willamette River (see section 4.2.1.2). While the increase in population and resulting urban, commercial, and industrial development that has occurred in the recent past may increase water demand, which could mean that minimum reservoir elevations are reached more frequently, which is the mechanism of concern for landslide initiation, the main driver of this change is more accurately described by RFFA 3.
- RFFA 1: Future population growth and accompanying urban, industrial, and commercial development. Although an increase in population and resulting urban, commercial, and industrial may increase water demand, which could mean that minimum reservoir elevations are reached more frequently, which is the mechanism of concern for landslide initiation, the main driver of this change is more properly placed in RFFA 3.

- RFFA 2: Future agricultural development. While decreased projected cropland may marginally affect Willamette Basin hydrology and decrease water use, which has indirect effects on geology and soils, the main driver of this change is more properly placed in RFFA 3.
- RFFA 4: Decarbonizing the energy sector with renewable energy sources. Reduced demand for the extraction of fossil fuels is more properly described by RFFA 10, mining operations. Decarbonation of the energy sector would not change reservoir operations in a way that would influence landslide formation.
- RFFA 5: Federal and state wildlife and lands management. Based on the hydrologic cumulative effects assessment (section 4.3.3) changes to land management upstream of the WV projects is unlikely to cause changes large enough to alter flow into the reservoirs, therefore it is unlikely to affect the probability of deep reservoir drawdown which is the mechanism of concern for initiating landslide formation.
- RFFA 6: Fishery management and killer whales. The flow targets in the WVS are specific to the river reaches and habitat where they occur. They are not variable based on Pacific Ocean salmon returns. Therefore deep drawdowns to meet flow targets that could impact geologic deposits are not impacted by this factor.
- RFFA 8: Invasive species management. Does not affect reservoir regulation decisions for the WVS dams or removal of geologic materials.

Therefore, these RFFAs are dismissed from further analysis.

### 4.4.2 Cumulative Effects to Geology and Soils by Alternative

Construction of the Willamette Valley projects altered local geology because several necessary tasks for dam construction require removal of geologic materials. Foundation preparation at many locations involved stripping of overburden and unsuitable rock until competent rock was reached. Construction of the dam spillway and core trench often require blasting and excavation. Additionally, materials for the dam embankments are often excavated from local borrow areas. Initial filling and drawdown of the reservoir and activities associated with construction of the dam sometimes initiate landslides or steepen slopes so that rockfall and landslides are more likely. For example, at Lookout Point relocation of the highway and railroad during construction reactivated the Minnow slide deposit and the first drawdown of the reservoir formed the Voss slide (see section 3.4.1.6). Activities related to construction and the first fill and drawdown cycle of the reservoir-initiated soil creep and landslides at Cougar, Detroit, Dorena, Fall Creek, Green Peter, Hills Creek, Lookout Point. These landslides are likely to continue to occur during periods of very wet weather or reduction of the reservoir stage. Construction of other dams and reservoirs in the Willameete River Basin are unlikely to directly effect the formation of landslides at the Willamette Valley projects.

As discussed in section 3.3.3.1, there are several near-term operations related to the injunction that are expected to require deep drawdown of the reservoir that could result in moderate landslide effects at Lookout Point and Cougar, minor landslide effects at Green Peter, and negligible effects to landslides at Fall Creek. There are also projects may result in excavation of geologic materials. These effects are additive.

An increase to water withdrawals to meet municipal, industrial, and agricultural demand (RFFA 3) would result in more stored water being released from the reservoir to meet downstream flow targets, which may mean that in dry years reservoir levels will decrease more quickly to minimal pool elevations in order to meet flow targets. Water withdrawals would be additive effect on landslide formation.

This PEIS contains measures that would alter the flow targets downstream of the WVS dams to meet tribal, state, and local fish and wildlife improvement goals (RFFA 7). Under some alternatives during spring and summer of dry years reservoirs would need to be lowered more rapidly and would be drawn down deeper than the current minimum elevation in order to meet these targets. This effect would be additive for landslide formation.

Climate change (RFFA 9) is anticipated to reduce the amount of precipitation that falls as snow in the winter, which would cause basin-wide flows to be reduced earlier in spring than when it has historically occurred. This leads to an earlier reduction in reservoir water surface elevations starting in late spring through summer and fall. This increases the probability that the reservoir will be drawn down to its minimum elevation during dry years. This increases shoreline exposure and is an additive effect for landslide formation. Additionally, climate change is anticipated to increase the risk of forest fire. Because tree roots bind soil together, loss of trees due to forest fires increases the erodibility of soils and reduces the strength of slopes, allowing for otherwise stable slopes to initiate failure.

Removal of material associated with mining (RFFA 10) can result in over steepened slopes. Mining in areas where landslides are already present exacerbates existing slope stability issues. Green Peter and Lookout Point have mining claims located on mapped landslide areas that would have an additive effect on the environmental consequences of near-term operations and proposed alternatives.

The roots of trees have a stabilizing effect on soils and removing trees during timber and logging industry operations (RFFA 11) kills the roots, which can result in slope instability, especially in areas that have existing landslides and are already prone to slope failure. Cougar and Lookout Point have historic logging operations in areas containing landslides that would have an additive synergistic effect to landslide formation.

#### *4.4.2.1 No Action Alternative*

Combined with the effects of the RFFAs including climate change, there would likely be additional effects to geology (changes from existing condition) under the No Acton Alternative due to landslide formation. As discussed in section 3.4.3.1, the effects of the NAA do not appreciably change the geomorphology and sediment processes, or the closely related hydrology and hydraulics, of the WVS from the existing conditions. For all subbasins that are expected to have cumulative effects on the probability of landslides occurring due to past, current, and future actions under the NAA, the expected cumulative effect is additive, synergistic, indirect, and of unknown magnitude. However, any cumulative effect that increases the probability of landslide formation is not expected to change the scale of the effect from activation of landslides within the Santiam basin based on the criteria in section 3.3.1.

##### *4.4.2.1.1 Santiam Subbasin*

In the Santiam subbasin several RFFA's have an additive effect on environmental consequences under the NAA. Construction associated with Green Peter Dam initiated landslides that are in contact with the reservoir. Near term operations at Detroit and Green Peter would cause deeper drawdowns and increase the probability of landslide formation. Because no operations are proposed to meet flow targets that would cause a reduction in reservoir elevations in the Santiam Subbasin projects, no differential effects on landslide formation from fish and wildlife improvement is expected to occur. Mining claim activity at Green Peter (Causey, J.D., 2011; DOGAMI, 2022) and timber harvesting at Detroit (ODF, 2022) have occurred in areas with landslides, which would potentially destabilize slopes. Both increased water withdrawals due to demand and climate change have additive effects for Detroit and Green Peter. In summary, cumulative effects due to past, current, and future actions under the NAA are anticipated for Detroit and Green Peter, but not at Big Cliff or Foster. Big Cliff does not have existing landslide areas and Foster is not anticipated to have increased shoreline exposure, and therefore no environmental consequences due to landslides are expected under any alternative.

##### *4.4.2.1.2 Long Tom Subbasin*

There are no landslides in contact with the reservoir at Fern Ridge, therefore no environmental consequences due to landslides are expected under any alternative.

##### *4.4.2.1.3 McKenzie Subbasin*

In the McKenzie subbasin several RFFA's have an additive effect on environmental consequences under the NAA. Construction associated with Cougar Dam initiated landslides that are in contact with the reservoir. Near term operations at Cougar would cause deeper drawdowns and increase the probability of landslide formation. Because no operations are proposed to meet flow targets that would cause a reduction in reservoir elevation at Cougar no differential effects on landslide formation from fish and wildlife improvement is expected to occur. Timber harvesting has occurred in areas with landslides at Cougar (ODF, 2022), which would reduce slope stability. Both increased water withdrawals due to demand and climate change have effects for at Cougar. In summary, cumulative effects due to past, current, and future actions under the NAA are anticipated for Cougar, but not at Blue River, since it does not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

##### *4.4.2.1.4 Middle Fork of the Willamette Subbasin*

In the Middle Fork subbasin several RFFA's have an additive effect on environmental consequences under the NAA. Construction associated with Hills Creek and Lookout Point Dams initiated landslides that are in contact with the reservoirs. Near-term operations at Hills Creek and Lookout point would influence landslide formation. Because no operations are proposed to meet flow targets that would cause a reduction in reservoir elevation at Hills Creek and Lookout Point no differential effects on landslide formation from fish and wildlife improvement is expected to occur. Mining claim activity and timber harvesting at Lookout Point have occurred in areas with landslides (Causey, J.D., 2011; DOGAMI, 2022; ODF, 2022). Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Hills Creek and Lookout Point. In summary, cumulative effects due to past, current, and future actions under the NAA are anticipated for Hills Creek and Lookout Point, but not at Dexter or Fall Creek, since they do not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

##### *4.4.2.1.5 Coast Fork of the Willamette Subbasin*

Under the NAA, no Coast Fork subbasin projects are expected to have environmental consequences due to landslides.

#### ***4.4.2.2 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures***

Combined with the effects of the RFFAs including climate change, there would likely be additional effects to geology (changes from existing condition) under Alternative 1 due to conditions that increase the probability of landslide formation occurring. For all subbasins that are expected to have cumulative effects on the probability of landslides occurring due to past, current, and future actions under Alternative 1, the expected cumulative effect is additive, synergistic, indirect, and of unknown magnitude. However, any cumulative effect that increases the probability of landslide formation is not expected to change the scale of the effect from activation of landslides within the Santiam basin based on the criteria in section 3.4.1.

##### 4.4.2.2.1 Santiam Subbasin

In the Santiam subbasin several RFFA's have an additive effect on environmental consequences under Alternative 1. Construction associated with Green Peter Dam initiated landslides that are in contact with the reservoir. Near term operations at Detroit and Green Peter would cause deeper drawdowns and increase the probability of landslide formation. Because all measures that cause a reduction in reservoir elevation at Detroit and Green Peter are directly related to meeting flow targets, no differential effects on landslide formation are expected to occur. Mining claim activity at Green Peter (Causey, J.D., 2011; DOGAMI, 2022) and timber harvesting at Detroit (ODF, 2022) have occurred in areas with landslides. Both increased water withdrawals due to demand and climate change would have effects at Detroit and Green Peter. In summary, cumulative effects due to past, current, and future actions under Alternative 1 are anticipated for Detroit and Green Peter, but not at Big Cliff or Foster. Big Cliff does not have existing landslide areas and Foster is not anticipated to have increased shoreline exposure, and therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.2.2 Long Tom Subbasin*

There are no landslides in contact with the reservoir at Fern Ridge, therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.2.3 McKenzie Subbasin*

In the McKenzie subbasin several RFFA's have an additive effect on environmental consequences under the Alternative 1. Construction associated with Cougar Dam initiated landslides that are in contact with the reservoir. Deep drawdowns at Cougar related to near term operations are anticipated to increase shoreline exposure and may decrease slope stability due to erosion and small-scale slope failures in areas that have existing landslides. Because all measures that cause a reduction in reservoir elevation at Cougar are directly related to meeting flow targets, no differential effects on landslide formation are expected to occur. Timber harvesting has occurred in areas with landslides at Cougar (ODF, 2022), which would further destabilize slopes. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Cougar. In summary, cumulative effects due to past, current, and future actions under Alternative 1 are anticipated for Cougar, but not at Blue River because it does not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.2.4 Middle Fork of the Willamette Subbasin*

In the Middle Fork subbasin several RFFA's have an additive effect on environmental consequences under the Alternative 1. Construction associated with Hills Creek and Lookout Point Dams initiated landslides that are in contact with the reservoirs. Deep drawdowns at Lookout Point related to near term operations are anticipated to increase shoreline exposure and may decrease slope stability due to erosion and small-scale slope failures in areas that have existing landslides. Because all measures that cause a reduction in reservoir elevation at Hills Creek and Lookout Point are directly related to meeting flow targets, no differential effects on landslide formation are expected to occur. Mining claim activity and timber harvesting at Lookout Point have occurred in areas with landslides (Causey, J.D., 2011; DOGAMI, 2022; ODF, 2022). Both increased water withdrawals due to demand and climate change would have synergistic additive effects for environmental consequences at Hills Creek and Lookout Point. In summary, cumulative effects due to past, current, and future actions under Alternative 1 are anticipated for Hills Creek and Lookout Point, but not at Dexter or Fall Creek, since they do not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

##### *4.4.2.2.5 Coast Fork of the Willamette Subbasin*

In the Coast Fork subbasin several RFFA's have an additive effect on environmental consequences under the Alternative 1. Construction associated with Dorena Dam initiated landslides that are in contact with the reservoir. Because all measures that cause a reduction in reservoir elevation at Dorena are directly related to meeting flow targets, no differential effects on landslide formation are expected to occur. Timber harvesting has occurred in areas with landslides at Dorena (ODF, 2022). Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Dorena. Based on the cumulative effects of past, current, and future actions under alternative 1 are anticipated for Dorena, but not at Cottage Grove, since it does not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

#### ***4.4.2.3 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative***

Combined with the effects of the RFFAs including climate change, there would likely be additional effects to geology (changes from existing condition) under Alternative 2A due to conditions that increase the probability of landslide formation occurring. For all subbasins that are expected to have cumulative effects on the probability of landslides occurring due to past, current, and future actions under Alternative 2A, the expected cumulative effect is additive, synergistic, indirect, and of unknown magnitude. However, any cumulative effect that increases the probability of landslide formation is not expected to change the scale of the effect from activation of landslides within the Santiam basin based on the criteria in section 3.4.1.

##### *4.4.2.3.1 Santiam Subbasin*

In the Santiam subbasin several RFFA's have an additive effect on environmental consequences under Alternative 2A. Construction associated with Green Peter Dam initiated landslides that are in contact with the reservoir and would have an additive effect on environmental consequences due to landslides under alternative 2A. Near term operations at Detroit would cause deeper drawdowns and increase the probability of landslide formation. Near term operations at Green Peter are the same as the deeper fall reservoir drawdown for downstream fish passage under alternative 2A, so no incremental difference due to near term operations is expected for this project. Changes to flow targets under alternative 2A means that drawdowns down to above the RO at Green Peter are more likely to occur compared with the NAA. Mining claim activity at Green Peter (Causey, J.D., 2011; DOGAMI, 2022) and timber harvesting at Detroit (ODF, 2022) have occurred in areas with landslides. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Detroit and Green Peter. In summary, cumulative effects due to past, current, and future actions under Alternative 2A are anticipated for Detroit and Green Peter, but not at Big Cliff or Foster. Big Cliff does not have existing landslide areas and Foster is not anticipated to have increased shoreline exposure, and therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.3.2 Long Tom Subbasin*

There are no landslides in contact with the reservoir at Fern Ridge, therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.3.3 McKenzie Subbasin*

In the McKenzie subbasin several RFFA's have an additive effect on environmental consequences under the Alternative 2A. Construction associated with Cougar Dam initiated landslides that are in contact with the reservoir. Deep drawdowns at Cougar related to near term operations are anticipated to increase shoreline exposure and may decrease slope stability due to erosion and small-scale slope failures in areas that have existing landslides. Because all measures that cause a reduction in reservoir elevation at Cougar are directly related to meeting flow targets, no differential effects on landslide formation are expected to occur. Timber harvesting has occurred in areas with landslides at Cougar (ODF, 2022), which would further destabilize slopes. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Cougar. In summary, cumulative effects due to past, current, and future actions under Alternative 2A are anticipated for Cougar, but not at Blue River because it does not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.3.4 Middle Fork of the Willamette Subbasin*

In the Middle Fork subbasin several RFFA's have an additive effect on environmental consequences under the alternative 2A. Construction associated with Hills Creek and Lookout Point Dams initiated landslides that are in contact with the reservoirs. Deep drawdowns at Lookout Point related to near term operations are anticipated to increase shoreline exposure and may decrease slope stability due to erosion and small-scale slope failures in areas that have existing landslides. Because all measures that cause a reduction in reservoir elevation at Hills Creek and Lookout Point are directly related to meeting flow targets, no differential effects on landslide formation are expected to occur. Mining claim activity and timber harvesting at Lookout Point have occurred in areas with landslides (Causey, J.D., 2011; DOGAMI, 2022; ODF, 2022). Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Hills Creek and Lookout Point. Based on the cumulative effects of past, current, and future actions under alternative 2A are anticipated for Hills Creek and Lookout Point, but not at Dexter or Fall Creek, since they do not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.3.5 Coast Fork of the Willamette Subbasin*

Under alternative 2A no Coast Fork Willamette subbasin projects are expected to have environmental consequences due to landslides.

### *4.4.2.4 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Combined with the effects of the RFFAs including climate change, there would likely be additional effects to geology (changes from existing condition) under Alternative 2B due to conditions that increase the probability of landslide formation occurring. For all subbasins that are expected to have cumulative effects on the probability of landslides occurring due to past, current, and future actions under Alternative 2B, the expected cumulative effect is additive, synergistic, indirect, and of unknown magnitude. However, any cumulative effect that increases the probability of landslide formation is not expected to change the scale of the effect from activation of landslides within the Santiam basin based on the criteria in section 3.4.1.

#### *4.4.2.4.1 Santiam Subbasin*

In the Santiam subbasin several RFFA's have an additive effect on environmental consequences under Alternative 2b. Construction associated with Green Peter Dam initiated landslides that are in contact with the reservoir and would have an additive effect on environmental consequences due to landslides under alternative 2B. Near term operations at Detroit would cause deeper drawdowns and increase the probability of landslide formation. Near term operations at Green Peter are the same as the deeper fall reservoir drawdown for downstream fish passage under alternative 2B, so no incremental difference due to near term operations is expected for this project. Changes to flow targets under alternative 2B means that drawdowns down to above the RO at Green Peter are more likely to occur compared with the NAA, changes to flow targets have an additive effect to the environmental consequences due to landslides. Mining claim activity at Green Peter (Causey, J.D., 2011; DOGAMI, 2022) and timber harvesting at Detroit have occurred in areas with landslides (ODF, 2022), which would have an additive effect on environmental consequences. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Detroit and Green Peter. In summary, cumulative effects due to past, current, and future actions under Alternative 2B are anticipated for Detroit and Green Peter, but not at Big Cliff or Foster. Big Cliff does not have existing landslide areas and Foster is not anticipated to have increased shoreline exposure, and therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.4.2 Long Tom Subbasin*

There are no landslides in contact with the reservoir at Fern Ridge, therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.4.3 McKenzie Subbasin*

In the McKenzie subbasin several RFFA's have an additive effect on environmental consequences under the Alternative 2b. Construction associated with Cougar Dam initiated landslides that are in contact with the reservoir. Deep drawdowns at Cougar related to near term operations are anticipated to increase shoreline exposure and may decrease slope stability due to erosion and small-scale slope failures in areas that have existing landslides. Because all measures that cause a reduction in reservoir elevation at Cougar are directly related to meeting flow targets, no differential effects on landslide formation are expected to occur. Timber harvesting has occurred in areas with landslides at Cougar (ODF, 2022), which would further destabilize slopes. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Cougar. In summary, cumulative effects due to past, current, and future actions under Alternative 2B are anticipated for Cougar, but not at Blue River because it does not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

##### *4.4.2.4.4 Middle Fork of the Willamette Subbasin*

In the Middle Fork subbasin several RFFA's have an additive effect on environmental consequences under the alternative 2B. Construction associated with Hills Creek and Lookout Point Dams initiated landslides that are in contact with the reservoirs. Deep drawdowns at Lookout Point related to near term operations are anticipated to increase shoreline exposure and may decrease slope stability due to erosion and small-scale slope failures in areas that have existing landslides. Because all measures that cause a reduction in reservoir elevation at Hills Creek and Lookout Point are directly related to meeting flow targets, no differential effects on landslide formation are expected to occur. Mining claim activity and timber harvesting at Lookout Point (Causey, J.D., 2011; DOGAMI, 2022; ODF, 2022) have occurred in areas with landslides. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Hills Creek and Lookout Point. Based on the cumulative effects of past, current, and future actions under alternative 2B are anticipated for Hills Creek and Lookout Point, but not at Dexter or Fall Creek, since they do not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

##### *4.4.2.4.5 Coast Fork of the Willamette Subbasin*

Under alternative 2B no Coast Fork subbasin projects are expected to have environmental consequences due to landslides.

#### ***4.4.2.5 Alternative 3A – Operations-Focused Fish Passage Alternative***

Combined with the effects of the RFFAs including climate change, there would likely be additional effects to geology (changes from existing condition) under Alternative 3A due to conditions that increase the probability of landslide formation occurring. For all subbasins that are expected to have cumulative effects on the probability of landslides occurring due to past, current, and future actions under Alternative 3A, the expected cumulative effect is additive, synergistic, indirect, and of unknown magnitude. However, any cumulative effect that increases the probability of landslide formation is not expected to change the scale of the effect from activation of landslides within the Santiam basin based on the criteria in section 3.4.1

#### *4.4.2.5.1 Santiam Subbasin*

In the Santiam subbasin several RFFA's have an additive effect on environmental consequences under Alternative 3a. Construction associated with Green Peter Dam initiated landslides that are in contact with the reservoir. Near term operations at Detroit would cause deeper drawdowns and increase the probability of landslide formation. Near term operations at Green Peter are the same as the deeper fall reservoir drawdown for downstream fish passage under alternative 3A, so no incremental difference due to near term operations is expected for this project. Changes to flow targets under alternative 3A means that drawdowns down to above the RO at Detroit and Green Peter are more likely to occur compared with the NAA, changes to flow targets have an additive effect to the environmental consequences due to landslides. Mining claim activity at Green Peter (Causey, J.D., 2011; DOGAMI, 2022) and timber harvesting at Detroit have occurred in areas with landslides (ODF, 2022). Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Detroit and Green Peter. In summary, cumulative effects due to past, current, and future actions under Alternative 3A are anticipated for Detroit and Green Peter, but not at Big Cliff or Foster. Big Cliff does not have existing landslide areas and Foster is not anticipated to have increased shoreline exposure, and therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.5.2 Long Tom Subbasin*

There are no landslides in contact with the reservoir at Fern Ridge, therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.5.3 McKenzie Subbasin*

In the McKenzie subbasin several RFFA's have an additive effect on environmental consequences under the Alternative 3a. Construction associated with Cougar Dam initiated landslides that are in contact with the reservoir. Deep drawdowns at Cougar related to near term operations would increase shoreline exposure and may decrease slope stability due to erosion and small-scale slope failures in areas that have existing landslides, but because the near term operation is the same as the deeper fall reservoir drawdown for downstream fish passage under alternative 3A, no incremental difference due to near term operations is expected for this project. Changes to flow targets under alternative 3A means that drawdowns down to above the RO at Cougar are more likely to occur compared with the NAA, changes to flow targets have an additive effect to the environmental consequences on landslides. Timber harvesting has occurred in areas with landslides at Cougar (ODF, 2022), which would further destabilize slopes. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Cougar. In summary, cumulative effects due to past, current, and future actions under Alternative 3A are anticipated for Cougar, but not at Blue River because it does not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.5.4 Middle Fork of the Willamette Subbasin*

In the Middle Fork subbasin several RFFA's have an additive effect on environmental consequences under the alternative 3A. Construction associated with Hills Creek and Lookout Point Dams initiated landslides that are in contact with the reservoirs. Near term operations at Lost Creek are the same as the deeper fall reservoir drawdown for downstream fish passage under alternative 3A, so no incremental difference due to near term operations is expected for this project. Changes to flow targets under alternative 3A means that drawdowns down to above the RO at Hills Creek and Lookout Point are more likely to occur compared with the NAA, changes to flow targets have an additive effect to the environmental consequences due to landslides. Mining claim activity (Causey, J.D., 2011; DOGFAMI, 2022) and timber harvesting at Lookout Point have occurred in areas with landslides (ODF, 2022), which would have an additive effect on environmental consequences. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Hills Creek and Lookout Point. Based on the cumulative effects of past, current, and future actions under alternative 3A are anticipated for Lookout Point, but not at Hills Creek, Dexter, or Fall Creek. Hills Creek does not have anticipated environmental consequences under this alternative and Dexter and Fall Creek do not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.5.5 Coast Fork of the Willamette Subbasin*

In the Coast Fork subbasin, construction associated with Dorena Dam initiated landslides that are in contact with the reservoir and would have an additive effect on environmental consequences due to landslides under alternative 3A. Because all measures that cause a reduction in reservoir elevation at Dorena are directly related to meeting flow targets, no differential effects on landslide formation are expected to occur. Timber harvesting has occurred in areas with landslides at Dorena (ODF, 2022), which would have an additive effect on environmental consequences. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Dorena. Based on the cumulative effects of past, current, and future actions under alternative 3A are anticipated for Dorena, but not at Cottage Grove, since it does not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

### ***4.4.2.6 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)***

Combined with the effects of the RFFAs including climate change, there would likely be additional effects to geology (changes from existing condition) under Alternative 3B due to conditions that increase the probability of landslide formation occurring. For all subbasins that are expected to have cumulative effects on the probability of landslides occurring due to past, current, and future actions under Alternative 3B, the expected cumulative effect is additive, synergistic, indirect, and of unknown magnitude. However, any cumulative effect that increases the probability of landslide formation is not expected to change the scale of the effect from activation of landslides within the Santiam basin based on the criteria in section 3.4.1

#### *4.4.2.6.1 Santiam Subbasin*

In the Santiam subbasin several RFFA's have an additive effect on environmental consequences under Alternative 3b. Construction associated with Green Peter Dam initiated landslides that are in contact with the reservoir and would have an additive effect on environmental consequences due to landslides under alternative 3B. Near term operations at Detroit would cause deeper drawdowns and increase the probability of landslide formation. Near term operations at Green Peter are the same as the deeper fall reservoir drawdown for downstream fish passage under alternative 3B, so no incremental difference due to near term operations is expected for this project. Changes to flow targets under alternative 3B means that drawdowns down to above the RO at Detroit and Green Peter are more likely to occur compared with the NAA, changes to flow targets have an additive effect to the environmental consequences due to landslides. Mining claim activity at Green Peter (Causey, J.D., 2011; DOGAMI, 2022) and timber harvesting at Detroit have occurred in areas with landslides (ODF, 2022), which would have an additive effect on environmental consequences. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Detroit and Green Peter. In summary, cumulative effects due to past, current, and future actions under Alternative 3A are anticipated for Detroit and Green Peter, but not at Big Cliff or Foster. Big Cliff does not have existing landslide areas and Foster is not anticipated to have increased shoreline exposure, and therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.6.2 Long Tom Subbasin*

There are no landslides in contact with the reservoir at Fern Ridge, therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.6.3 McKenzie Subbasin*

In the McKenzie subbasin several RFFA's have an additive effect on environmental consequences under the Alternative 3B. Construction associated with Cougar Dam initiated landslides that are in contact with the reservoir. Deep drawdowns at Cougar related to near term operations are anticipated to increase shoreline exposure and may decrease slope stability due to erosion and small-scale slope failures in areas that have existing landslides. Changes to flow targets under alternative 3B means that drawdowns down to above the RO at Cougar are more likely to occur compared with the NAA, which would potentially initiate landslide formation. Timber harvesting has occurred in areas with landslides at Cougar (ODF, 2022), which would decrease slope stability. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Cougar. In summary, cumulative effects due to past, current, and future actions under Alternative 3A are anticipated for Cougar, but not at Blue River because it does not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.6.4 Middle Fork of the Willamette Subbasin*

In the Middle Fork subbasin, construction associated with Hills Creek and Lookout Point Dams initiated landslides that are in contact with the reservoirs and would have an additive effect on environmental consequences due to landslides under alternative 3B. Near term operations at Lost Creek are the same as the deeper fall reservoir drawdown for downstream fish passage under alternative 3B, so no incremental difference due to near term operations is expected for this project. Because all measures that cause a reduction in reservoir elevation at Hills Creek and Lookout Point are directly related to meeting flow targets, no differential effects on landslide formation are expected to occur. Mining claim activity and timber harvesting at Lookout Point have occurred in areas with landslides (Causey, J.D., 2011; DOGAMI, 2022; ODF, 2022), which would have an additive effect on environmental consequences. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Hills Creek and Lookout Point. Based on the cumulative effects of past, current, and future actions under alternative 3B are anticipated for Lookout Point, but not at Hills Creek, Dexter, or Fall Creek. Hills Creek does not have anticipated environmental consequences under this alternative and Dexter and Fall Creek do not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.6.5 Coast Fork of the Willamette Subbasin*

In the Coast Fork subbasin, construction associated with Dorena Dam initiated landslides that are in contact with the reservoir and would have an additive effect on environmental consequences due to landslides under alternative 3B. Because all measures that cause a reduction in reservoir elevation at Dorena are directly related to meeting flow targets, no differential effects on landslide formation are expected to occur. Timber harvesting has occurred in areas with landslides at Dorena (ODF, 2022), which would have an additive effect on environmental consequences. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Dorena. Based on the cumulative effects of past, current, and future actions under alternative 3B are anticipated for Dorena, but not at Cottage Grove, since it does not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

### ***4.4.2.7 Alternative 4 – Structures-Based Fish Passage Alternative***

Combined with the effects of the RFFAs including climate change, there would likely be additional effects to geology (changes from existing condition) under Alternative 4 due to conditions that increase the probability of landslide formation occurring. For all subbasins that are expected to have cumulative effects on the probability of landslides occurring due to past, current, and future actions under Alternative 4, the expected cumulative effect is additive, synergistic, indirect, and of unknown magnitude. However, any cumulative effect that increases the probability of landslide formation is not expected to change the scale of the effect from activation of landslides within the Santiam basin based on the criteria in section 3.4.1

#### *4.4.2.7.1 Santiam Subbasin*

In the Santiam subbasin several RFFA's have an additive effect on environmental consequences under Alternative 4. Construction associated with Green Peter Dam initiated landslides that are in contact with the reservoir and would have an additive effect on environmental consequences due to landslides under alternative 4. Near term operations at Detroit and Green Peter would cause deeper drawdowns and increase the probability of landslide formation. Because all measures that cause a reduction in reservoir elevation at Detroit and Green Peter are directly related to meeting flow targets, no differential effects on landslide formation would occur. Mining claim activity at Green Peter (Causey, J.D., 2011; DOGAMI, 2022) and timber harvesting at Detroit have occurred in areas with landslides (ODF, 2022), which would have an additive effect on environmental consequences. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Detroit and Green Peter. In summary, cumulative effects due to past, current, and future actions under Alternative 4 are anticipated for Detroit and Green Peter, but not at Big Cliff or Foster. Big Cliff does not have existing landslide areas and Foster is not anticipated to have increased shoreline exposure, and therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.7.2 Long Tom Subbasin*

There are no landslides in contact with the reservoir at Fern Ridge, therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.7.3 McKenzie Subbasin*

In the McKenzie subbasin several RFFA's have an additive effect on environmental consequences under the Alternative 4. Construction associated with Cougar Dam initiated landslides that are in contact with the reservoir. Deep drawdowns at Cougar related to near term operations are anticipated to increase shoreline exposure and may decrease slope stability due to erosion and small-scale slope failures in areas that have existing landslides. Because all measures that cause a reduction in reservoir elevation at Cougar are directly related to meeting flow targets, no differential effects on landslide formation are expected to occur. Timber harvesting has occurred in areas with landslides at Cougar (ODF, 2022), which would have an additive effect on environmental consequences. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Cougar. In summary, cumulative effects due to past, current, and future actions under Alternative 3A are anticipated for Cougar, but not at Blue River because it does not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.7.4 Middle Fork of the Willamette Subbasin*

In the Middle Fork subbasin several RFFA's have an additive effect on environmental consequences under the alternative 4. Construction associated with Hills Creek and Lookout Point Dams initiated landslides that are in contact with the reservoirs. Deep drawdowns at Lookout Point related to near term operations are anticipated to increase shoreline exposure and may decrease slope stability due to erosion and small-scale slope failures in areas that have existing landslides. Because all measures that cause a reduction in reservoir elevation at Hills Creek and Lookout Point are directly related to meeting flow targets, no differential effects on landslide formation are expected to occur. Mining claim activity and timber harvesting at Lookout Point (Causey, J.D., 2011; DOGAMI, 2022; ODF, 2022) have occurred in areas with landslides. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Hills Creek and Lookout Point. Based on the cumulative effects of past, current, and future actions under alternative 4 are anticipated for Hills Creek and Lookout Point, but not at Dexter or Fall Creek, since they do not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.7.5 Coast Fork of the Willamette Subbasin*

In the Coast Fork subbasin, construction associated with Dorena Dam initiated landslides that are in contact with the reservoir and would have an additive effect on environmental consequences due to landslides under alternative 4. Because all measures that cause a reduction in reservoir elevation at Dorena are directly related to meeting flow targets, no differential effects on landslide formation are expected to occur. Timber harvesting has occurred in areas with landslides at Dorena (ODF, 2022), which would have an additive effect on environmental consequences. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Dorena. Based on the cumulative effects of past, current, and future actions under alternative 4 are anticipated for Dorena, but not at Cottage Grove, since it does not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

### *4.4.2.8 Alternative 5 – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Combined with the effects of the RFFAs including climate change, there would likely be additional effects to geology (changes from existing condition) under Alternative 2B due to conditions that increase the probability of landslide formation occurring. For all subbasins that are expected to have cumulative effects on the probability of landslides occurring due to past, current, and future actions under Alternative 2B, the expected cumulative effect is additive, synergistic, indirect, and of unknown magnitude. However, any cumulative effect that increases the probability of landslide formation is not expected to change the scale of the effect from activation of landslides within the Santiam basin based on the criteria in section 3.4.1

#### *4.4.2.8.1 Santiam Subbasin*

In the Santiam subbasin several RFFA's have an additive effect on environmental consequences under Alternative 5. Construction associated with Green Peter Dam initiated landslides that are in contact with the reservoir and would have an additive effect on environmental consequences due to landslides under alternative 5. Near term operations at Detroit and Green Peter would cause deeper drawdowns and increase the probability of landslide formation. Changes to flow targets under alternative 5 means that drawdowns down to above the RO at Green Peter are more likely to occur compared with the NAA, changes to flow targets have an additive effect to the environmental consequences due to landslides. Mining claim activity at Green Peter (Causey, J.D., 2011; DOGAMI, 2022) and timber harvesting at Detroit have occurred in areas with landslides (ODF, 2022), which would have an additive effect on environmental consequences. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Detroit and Green Peter. In summary, cumulative effects due to past, current, and future actions under Alternative 5 are anticipated for Detroit and Green Peter, but not at Big Cliff or Foster. Big Cliff does not have existing landslide areas and Foster is not anticipated to have increased shoreline exposure, and therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.8.2 Long Tom Subbasin*

There are no landslides in contact with the reservoir at Fern Ridge, therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.8.3 McKenzie Subbasin*

In the McKenzie subbasin several RFFA's have an additive effect on environmental consequences under the Alternative 5. Construction associated with Cougar Dam initiated landslides that are in contact with the reservoir. Deep drawdowns at Cougar related to near term operations are anticipated to increase shoreline exposure and may decrease slope stability due to erosion and small-scale slope failures in areas that have existing landslides. Changes to flow targets under alternative 5 means that drawdowns down to above the RO at Cougar are more likely to occur compared with the NAA, changes to flow targets have an additive effect to the environmental consequences on landslides. Timber harvesting has occurred in areas with landslides at Cougar (ODF, 2022), which would have an additive effect on environmental consequences. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Cougar. Based on the cumulative effects of past, current, and future actions under alternative 5, an additive indirect effect of unknown magnitude on the probability of landslides occurring is expected. However, this probability increase is not expected to change the scale of the effect from activation of landslides within the McKenzie subbasin based on the criteria in section 3.3.1.

#### *4.4.2.8.4 Middle Fork of the Willamette Subbasin*

In the Middle Fork subbasin several RFFA’s have an additive effect on environmental consequences under the alternative 5. Construction associated with Hills Creek and Lookout Point Dams initiated landslides that are in contact with the reservoirs. Deep drawdowns at Lookout Point related to near term operations are anticipated to increase shoreline exposure and may decrease slope stability due to erosion and small-scale slope failures in areas that have existing landslides. Because all measures that cause a reduction in reservoir elevation at Hills Creek and Lookout Point are directly related to meeting flow targets, no differential effects on landslide formation are expected to occur. Mining claim activity and timber harvesting at Lookout Point (Causey, J.D., 2011; DOGAMI, 2022; ODF, 2022) have occurred in areas with landslides. Both increased water withdrawals due to demand and climate change have synergistic additive effects for environmental consequences at Hills Creek and Lookout Point. Based on the cumulative effects of past, current, and future actions under alternative 5 are anticipated for Hills Creek and Lookout Point, but not at Dexter or Fall Creek, since they do not have existing landslide areas and therefore no environmental consequences due to landslides are expected under any alternative.

#### *4.4.2.8.5 Coast Fork of the Willamette Subbasin*

Under Alternative 5 no Coast Fork subbasin projects are expected to have environmental consequences due to landslides.

## 4.5 WATER QUALITY

### 4.5.1 Cumulative Effects Analysis Methodology for Water Quality

#### *4.5.1.1 Cumulative Actions Applicable to Water Quality*

Past, present, and RFFAs that, when considered together with the Proposed Action and alternatives, would have cumulative effects on Water Quality, include:

- RFFA 1: Future population growth and accompanying urban, industrial, and commercial development.
- RFFA 2: Reduced agriculture production
- RFFA 3: Water withdrawals for municipal, industrial, and agricultural uses
- RFFA 4: Decarbonizing the energy sector with renewable energy sources.
- RFFA 5: Federal and state wildlife and lands management
- RFFA 7: Tribal, state, and local fish and wildlife improvement.
- RFFA 8: Invasive species management.
- RFFA 9: Climate change
- RFFA 10: Mining operations.

Some of the other RFFAs discussed in Section 4.2.3 would not occur at or in close proximity to the WVS dams and reservoirs and as such would not have a cumulative effect on Water Quality. Had they occurred at or in close proximity to the WVS dams and reservoirs, they would have contributed to cumulative effects for Water Quality.

- RFFA 6: Fishery management and Killer Whales. No direct effect to Water Quality as this is managing effects of fisheries on Chinook, including UWR Chinook, and survivability of Killer Whales.
- RFFA 11: Timber and logging industry operations. Water Quality would not be affected as the Willamette Valley is not projected to be a focus of timber and logging operations in the foreseeable future.

Therefore, these RFFAs are dismissed from further analysis.

### 4.5.2 Cumulative Effects to Water Quality by Alternative

Construction of the Willamette Valley dams has changed downstream water temperatures to be unnaturally cool in the summer and warm in the winter. As water is released over the spillway this creates Total Dissolved Gas (TDG) which can be detrimental to aquatic species. Increased turbidity levels typically occur due to drawdown operations of the reservoir or high flow events due to precipitation. During construction of the WVS dams' contaminants may have been introduced which may require removal.

Future population growth, urban, industrial, and commercial development (RFFA 1) may cause adverse effects due to an increase in water demand and potential runoff downstream of the WVS dams. An increase in runoff may introduce non-point and point source pollution which would affect water quality. An increase in the source pollution inputs may contain contaminants and nutrient inputs. Increased nutrient inputs may also facilitate harmful algae bloom growth. Water demand from population growth and development could cause an increase in water temperatures due to a decrease of instream flow.

Reduced agricultural production (RFFA 2) would decrease cropland and potentially reduce water demands for irrigation although conversely this is due to an increase population growth and accompanying urban, industrial, and commercial development (RFFA 1). A reduction of agricultural development is beneficial to water quality whereas an increase in population growth would adversely affect water quality.

There could be adverse effects from increased volumes of water withdrawals for Municipal, Industrial, and Agricultural Uses (RFFA 3). An increase in water withdrawals would likely affect instream water temperatures as less water would be available in water segments to keep temperatures cool. This would likely create unsuitable habitat for aquatic species.

There may be possible adverse effects due to Decarbonizing the energy sector with renewable energy sources (RFFA 4) due to the potential for an increase in lack-of-market/lack-of-turbine-capacity spill, which could lead to higher TDG levels. Conversely, decarbonizing, and electrifying transportation and other sectors could reduce involuntary spill from lack-of-market spill.

A cumulative effect of Federal and State Wildlife and Land Management (RFFA 5) with the actions proposed in this Draft PEIS may benefit Water Quality. Watershed protection and conservation projects may provide an improvement to aquatic habitat and species. Water Quality parameters, such as water temperature, may also benefit depending on the wildlife and land management strategies.

Tribal, state, and local fish and wildlife improvement (RFFA 7) may be beneficial to water quality. Conservation and restoration efforts may provide a benefit to water quality by providing an improvement to aquatic habitat and species. Water Quality parameter such as temperature may also benefit due to land management strategies.

Invasive species management (RFFA 8) would assist in removal of non-native species that are a detriment to native species by predation or competition for food sources. Invasive plant species, such as milfoil, have the potential to decrease dissolved oxygen levels in a water body. Low dissolved oxygen can adversely affect fish and aquatic species. Removal and replacement of native species would thereby have a positive effect on Water Quality.

Climate change (RFFA 9) would affect water quality due to an increase in air temperature which would increase water temperatures. Greenhouse gas emissions are comprised of carbon dioxide, nitrous oxide, methane, and ozone. An increase in air temperature due to greenhouse gases may cause an increase water temperature. These gases can also potentially lower pH levels in waters which can cause an unsuitable environment for aquatic species.

Mining operations (RFFA 11) has the potential to adversely affect water quality by introducing minerals and contaminants via runoff downstream of dams. Majority of identified mines occur in Douglas and Lane counties. Mines occurring in Lane County may adversely affect water quality for the Coast Fork Willamette, Middle Fork Willamette, and McKenzie subbasins.

**Table 4.5-1. Summary of Reasonably Foreseeable Future Actions Relevant to Water Quality**

| RFFA # | RFFA Description | Cumulative Impact Description |
|---|---|---|
| RFFA 1 | Future population growth and urban, industrial, and commercial development | There may be adverse effects from increased water demand which cause an increase of instream water temperatures and pollution due to increased stormwater runoff from these sectors [All Alternatives]. |
| RFFA 2 | Reduced agricultural production | Potential beneficial effect to water quality due to decrease in cropland and water demand [All Alternatives]. |
| RFFA 3 | Water withdrawals for municipal, industrial, and agricultural uses | An increase in water withdrawals may cause adverse effects for instream water temperatures [All Alternatives]. |
| RFFA 4 | Decarbonizing the energy sector with renewable energy sources | Possible adverse effects due to potential increase in lack-of-market/lack-of-turbine capacity spill, which may lead to higher TDG levels. Decarbonizing and utilizing electrical transportation may reduce involuntary spill from lack-of-market spill [All Alternatives]. |
| RFFA 5 | Federal and state wildlife and lands management | Potential beneficial effect to water quality due to habitat restoration and land use management [All Alternatives]. |
| RFFA 7 | Tribal, State, and local fish and wildlife improvement | Potential beneficial effect to water quality due to habitat restoration [All Alternatives]. |
| RFFA 8 | Invasive Species Management | Potential benefit in removal of oxygen depleting plant species. An adverse effect if chemicals are utilized for removal management [All Alternatives]. |
| RFFA 9 | Climate change | Potential adverse effects from increased air temperature may result in increased water temperatures. There is potential for higher winter water volumes and lower summer water volumes. Potential increased water volumes may necessitate increase spill causing elevated |

| RFFA # | RFFA Description | Cumulative Impact Description |
|---|---|---|
| | | TDG levels. A decrease in flow and water volumes in the summer may cause elevated instream water temperatures [All Alternatives]. |
| RFFA 11 | Mining Operations | Potential adverse effects due to contaminants entering waters via runoff [All Alternatives]. |

#### *4.5.2.1 No Action Alternative*

Within the Willamette Valley System water quality parameters include water temperature, TDG, Turbidity, HABs, and Mercury (Coast Fork Willamette). Under the No Action Alternative, the RFFA including Climate change has the greatest potential to alter these water quality parameters, please refer to section 3.6.3.1. As stated above, population growth along with municipal and industrial has the potential to increase instream water demand and stormwater run-off pollution. An increase of TDG exceedances may occur with decarbonizing the energy sector and lack of turbine capacity spill for hydropower generation. Non-point and point source pollution occurrence may increase in the due to mining operations and population growth. The summary of direct/indirect effects of the No Action Alternative are summarized in Table 3.5-9.

#### *4.5.2.2 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Cumulative effects to water quality for Alternative 1 measures and RFFA’s are described by Willamette Valley subbasins based on effects described in section 4.2.2. The summary of direct/indirect effects of Alternative 1 compared to the No Action Alternative are summarized in Table 3.5-13.

##### *4.5.2.2.1 North Santiam Subbasin*

Big Cliff downstream water temperatures observes a negligible effect of days below 18C during the summer and moderate benefit of days near temperature target from April through August with the inclusion of a Water Temperature Control tower at Detroit dam.

Structural improvements to reduce TDG at Detroit would have a major benefit at Big Cliff. Annual differences in number of days above 110% of TDG exceedances and below Detroit is reduced as compared to the NAA.

Turbidity has the potential to increase as there is a moderate change downstream of Detroit Dam in fine grained sediments entering Big Cliff run-of-reservoir. Turbidity may also increase with higher precipitation events anticipated due to Climate change.

HABs have the potential to increase as there is a major change in shoreline exposure and sediment re-entrainment at Detroit reservoir. A resuspension of sediment may make nutrients available and facilitate algae bloom growth.

Mercury has the potential to increase as there is a major change in shoreline exposure at Detroit reservoir, which creates the potential for an increase in methylation due to water fluctuations. However, there are no foreseeable increases in anoxic waters. Big Cliff reservoir is a run-of river project that operates in a small range of pool elevations and is not included for the shoreline exposure metric. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.2.2 South Santiam Subbasin*

Foster observes major adverse effects to downstream water temperatures of days below 18C during the summer, moderate beneficial effect from April through August, and negligible effect from September through March as compared to the NAA. Alternative 1 includes a water temperature control tower at Green Peter.

Structural improvements to reduce TDG at Green Peter and Foster would have a negligible effect as compared to the NAA.

Turbidity has the potential to increase as there is a moderate change of sediment supply in fine grained sediments entering Foster reservoir which may partially settle. Turbidity may also increase with higher precipitation events anticipated due to Climate change.

HABs has the potential to increase as there is a major change for shoreline exposure and sediment re-entrainment at Green Peter reservoir. Foster reservoir has the potential for negligible changes for shoreline exposure and sediment re-entrainment. A resuspension of sediment may make nutrients available and facilitate algae bloom growth. Cumulative actions including Climate change with increased air and water temperatures may increase the likelihood of bloom formation.

Mercury has the potential to increase as there is a major change in shoreline exposure at Green Peter reservoir there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Foster reservoir would be negligible for shoreline exposure metric. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.2.3 McKenzie Subbasin*

Cougar downstream water temperatures would observe a negligible effect as there is already a water temperature control tower on site. However, cumulative actions including Climate change, water demands and mainstem flow targets may minor additive adverse cumulative effects to water temperatures in the subbasin. Blue River is low priority for water temperature control.

A beneficial effect to TDG is observed when including structural improvement at Cougar. Blue River is not expected to change as the RO's are utilized and TDG levels would not be expected to change.

Turbidity has the potential to increase as fine-grained sediment supply passing downstream of Cougar observes a minor change and Blue River would observe a moderate change.

A major change in shoreline exposure is observed at Cougar and Blue River which may increase the potential for HAB growth. Sediment Re-entrainment has the potential for a moderate change at Cougar and major change for Blue River. A resuspension of sediment may make nutrients available and facilitate algae bloom growth. Cumulative actions including Climate change with increased air and water temperatures may increase the likelihood of bloom formation.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Cougar and Blue River reservoir there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.2.4 Middle Fork Willamette Subbasin*

Hills Creek would have a minor adverse effect to water temperature targets in the summer which would mean an increase of the days of cooler (<18C or 64F) released downstream water temperatures. The inclusion of a water temperature control tower at Lookout Point would affect Dexter downstream water temperatures as Dexter is a reregulating dam. Downstream water temperatures at Dexter would have a moderate adverse effect of days below 18C in the summer, although a minor benefit is observed for days near the target temperature from April through August.

Turbidity has the potential to increase as there is a moderate change of sediment supply in fine-grained sediments compared to the NAA passing out of Hills Creek into the Middle Fork Willamette above Lookout Point. Dexter reservoir would have potential for minor change in fine grained sediment and negligible potential for change in sediment supply downstream of Dexter Dam.

HABs have the potential to increase as a major change in shoreline exposure compared to the NAA is observed at Hills Creek and Lookout Point. Sediment Re-entrainment results in a major change for Hills Creek and minor change for Lookout Point. Fall Creek would observe negligible change and Dexter reservoir is a run-of-river project and is not included in these metrics. A resuspension of sediment may make nutrients available and facilitate algae bloom growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Hills Creek and Lookout Point reservoirs there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Fall Creek reservoir would see negligible change relative to the NAA. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

##### *4.5.2.2.5 Coast Fork Willamette and Long Tom Subbasin*

There are no measures for water temperature or TDG at Cottage Grove, Dorena or Fern Ridge as such conditions are expected to remain similar to the NAA. A decrease of water surface elevations at Cottage Grove and Dorena during conservation season may increase fine-grained sediment release which may affect Turbidity levels. Cumulative actions of operations and deeper drafts at Cottage Grove and Dorena would have a major change to shoreline exposure relative to the NAA which may affect the mercury methylation process and increase the potential for algal blooms by resuspension of sediment with nutrients. As the reservoir would fill in the fall and winter, the exposed shoreline would expect to increase the likelihood of the methylation process.

##### *4.5.2.2.6 Mainstem Willamette*

Mainstem Willamette at Albany and Salem water temperatures observe minor adverse temperature effects in the summer. A decrease of instream flows during conservation season, from late spring through early fall, along with cumulative actions of instream water withdrawals and Climate change may exacerbate water temperatures. The additional water storage at WVS reservoirs may alleviate the increase in summer water temperatures. Currently there are only summer water temperature targets for the Mainstem Willamette. Water quality parameters such as TDG, Turbidity, HABs are negligible or have not been reported as a concern.

#### ***4.5.2.3 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative***

Cumulative effects to water quality for Alternative 2A measures and RFFA’s are described by Willamette Valley subbasins based on effects described in section 4.2.2. The summary of direct/indirect effects of Alternative 2A compared to the No Action Alternative are summarized in Table 3.5-12.

##### *4.5.2.3.1 North Santiam Subbasin*

Big Cliff downstream water temperatures observes a negligible effect of days below 18C during the summer and moderate benefit of days near temperature target from April through August with the inclusion of a Water Temperature Control tower at Detroit dam.

A moderate benefit is observed at Detroit and Big Cliff for TDG levels as the annual difference in number of days above 110% TDG levels is less as compared to the NAA.

Turbidity has the potential to increase as there is a moderate change downstream of Detroit Dam in fine grained sediments entering Big Cliff reservoir and minor change of the fine-grained sediments passing downstream into the North Santiam. Adverse effects from RFFA's (section 4.2.2) may increase the potential for Turbidity.

HABs have the potential to change as there is a negligible change in head-of-reservoir sediment mobilization and a major change in shoreline exposure. A resuspension of sediment may make nutrients available and facilitate algae bloom growth. Adverse effects from RFFA's (section 4.2.2) may increase the potential growth.

Mercury has the potential to increase as there is a major change in shoreline exposure at Detroit reservoir, which creates the potential for an increase in methylation due to water fluctuations. However, there are no foreseeable increases in anoxic waters. Big Cliff reservoir is a run-of river project that operates in a small range of pool elevations and is not included for the shoreline exposure metric. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

##### *4.5.2.3.2 South Santiam Subbasin*

Foster observes negligible effects to downstream water temperatures with days below 18C (64.4F) during the summer with the use of the spillway for surface spill in the summer at Green Peter reservoir. Moderate beneficial effects to downstream water temperatures from April through August which may be due to the modifications to increase warm water releases through a Foster Warm Water Supply (FWWS) pipe and fish weir at Foster Dam. A minor beneficial effect from September through March may be due to the use the RO's discharge of colder water during fall and winter drawdown operations at Green Peter reservoir.

There are no measures for TDG abatement at Green Peter and Foster. Adverse effects to TDG levels are observed for both reservoirs which may be due to the increase of spill as compared to the NAA. A measure to use the spillway for surface spill in the summer at Green Peter may contribute to the increase of TDG levels.

Turbidity has the potential to increase as there is potential for major change of sediment supply in fine grained sediments entering Foster reservoir which may partially settle and may pass a moderate change of the fine-grained sediments downstream into the South Santiam. RFFA's with Adverse effects (section 4.2.2) and Climate change may increase turbidity as winter precipitation is projected to increase this may increase sediment downstream of the dams.

HABs have the potential to increase as there is a major change for shoreline exposure and sediment re-entrainment at Green Peter reservoir. A resuspension of sediment may make nutrients available and facilitate algae bloom growth. Cumulative actions including Climate change with increased air and water temperatures may increase the likelihood of bloom formation. Adverse effects from RFFA's (section 4.2.2) may increase the potential growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Green Peter reservoir there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Foster reservoir would be negligible for shoreline exposure metric. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.3.3 McKenzie Subbasin*

Cougar downstream water temperatures would observe a negligible effect as there is already a water temperature control tower on site although cumulative actions including Climate change, water demands and mainstem flow targets may alter this effect.

A negligible effect to TDG is observed as there are no TDG measures at Cougar. Blue River is not expected to change as the RO's are utilized and TDG levels would not be expected to change.

Turbidity has the potential to increase as fine-grained sediment supply passing downstream of Cougar would observe a minor change and Blue River would observe a moderate change.

A major change in shoreline exposure is observed at Cougar and Blue River which may increase the potential for HAB growth. Sediment Re-entrainment has the potential for a moderate change at Cougar and major change for Blue River. A resuspension of sediment may make nutrients available and facilitate algae bloom growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Cougar and Blue River reservoir there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.3.4 Middle Fork Willamette Subbasin*

There are no Water Temperature measures for the Middle Fork Willamette. Cumulative effects at Hills Creek and Lookout Point storing more water in the spring and increasing water surface elevations. Hills Creek would have a moderate adverse effect to water temperature targets in the summer which would mean an increase of the days of cooler (<18C or 64F) released downstream water temperatures. Downstream water temperatures at Dexter would have a negligible effect of downstream water temperatures as compared to the NAA.

TDG level effects would be negligible for Hills Creek and Dexter as there are no TDG measures and has no reduction of days of TDG exceedances for the year (Appendix D, Figure 2-35). Fall Creek reservoir does not have a TDG gage and effects would be similar to the NAA and Affected Environment.

Turbidity has the potential to increase as there is a moderate change of sediment supply in fine-grained sediments passing out of Hills Creek into the Middle Fork Willamette above Lookout Point. Dexter reservoir would have potential for minor change in fine grained sediment and negligible potential for change in sediment supply downstream of Dexter Dam.

HABs have the potential to increase as a major change in shoreline exposure is observed at Hills Creek and Lookout Point. Sediment Re-entrainment results in a major change for Hills Creek and minor change for Lookout Point. Fall Creek would observe negligible change and Dexter reservoir is a run-of-river project and is not included in these metrics. A resuspension of sediment may make nutrients available and facilitate algae bloom growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Hills Creek and Lookout Point reservoirs there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Fall Creek reservoir would see negligible change relative to the NAA. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

##### *4.5.2.3.5 Coast Fork Willamette and Long Tom Subbasin*

There are no water temperature or TDG measures at Cottage Grove, Dorena or Fern Ridge as such conditions are expected to remain similar to the NAA. Negligible effects are expected for Turbidity, HABs and Mercury. Cumulative effects of RFFA's with adverse effects (section 4.2.2) to water quality may occur but it is unknown to what degree.

##### *4.5.2.3.6 Mainstem Willamette*

Mainstem Willamette at Albany and Salem water temperatures observes negligible effects to water temperature in the summer. A decrease of instream flows during conservation season, from late spring through early fall, along with cumulative actions of instream water withdrawals and Climate change may exacerbate water temperatures. Currently there are only summer water temperature targets for the Mainstem Willamette. TDG gages are not located on the Willamette River as TDG concerns are typically located downstream of WVS dams. There is a negligible potential for changes in sediment supply relative to the NAA in the Middle Willamette free-flowing reach as such Turbidity is not expected to increase. HABs are not expected as there are no OHA advisories near Albany and Salem in public records. Cumulative effects of RFFA's with adverse effects (section 4.2.2) to water quality may occur but it is unknown to what degree.

#### ***4.5.2.4 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative***

Cumulative effects to water quality for Alternative 2B measures and RFFA's are described by Willamette Valley subbasins based on effects described in section 4.2.2. The summary of direct/indirect effects of Alternative 2B compared to the No Action Alternative are summarized in Table 3.5-16.

#### *4.5.2.4.1 North Santiam Subbasin*

Big Cliff downstream water temperatures observes a negligible effect of days below 18C (64.4F) during the summer and moderate benefit of days near temperature target from April through August and major benefit for days near temperature target from September through March with the inclusion of a Water Temperature Control tower at Detroit dam.

No TDG measures are included in Alternative 2B although a moderate benefit is observed at Detroit and Big Cliff for TDG levels as the annual difference in number of days above 110% TDG levels is less as compared to the NAA.

Turbidity has the potential to increase as there is a moderate change downstream of Detroit Dam in fine grained sediments entering Big Cliff reservoir and minor change of the fine-grained sediments passing downstream into the North Santiam. Adverse effects from RFFA's (section 4.2.2) may increase the potential for Turbidity.

HABs have the potential to increase at Detroit Reservoir as there is a major change in shoreline exposure and sediment re-entrainment. A resuspension of sediment may make nutrients available and facilitate algae bloom growth. Adverse effects from RFFA's (section 4.2.2) may increase the potential growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Detroit reservoir, which creates the potential for an increase in methylation due to water fluctuations. However, there are no foreseeable increases in anoxic waters. Big Cliff reservoir is a run-of river project that operates in a small range of pool elevations and is not included for the shoreline exposure metric. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.4.2 South Santiam Subbasin*

Foster observes negligible effects to downstream water temperatures with days below 18C (64.4F) during the summer with the use of the spillway for surface spill in the summer at Green Peter reservoir. Moderate beneficial effects to downstream water temperatures from April through August which may be due to the modifications to increase warm water releases through a Foster Warm Water Supply (FWWS) pipe and fish weir at Foster Dam. A minor beneficial effect from September through March may be due to the use the RO's discharge of colder water during fall and winter drawdown operations at Green Peter reservoir.

There are no measures for TDG abatement at Green Peter and Foster. Major adverse effects to TDG levels are observed at Green Peter and moderate adverse effect at Foster reservoirs which may be due to the increase of spill as compared to the NAA. A measure to use the spillway for surface spill in the summer at Green Peter may contribute to the increase of TDG levels.

Turbidity has the potential to increase as there is potential for major change of sediment supply in fine grained sediments entering Foster reservoir which may partially settle and may pass a moderate change of the fine-grained sediments downstream into the South Santiam. RFFA's with Adverse effects (section 4.2.2) and Climate change may increase Turbidity as winter precipitation is projected to increase this may increase sediment downstream of the dams.

HABs have the potential to increase as there is a major change for head-of-reservoir sediment mobilization, shoreline exposure and sediment re-entrainment at Green Peter reservoir. A resuspension of sediment may make nutrients available and facilitate algae bloom growth. Foster reservoir has a minor change for potential head-of-reservoir sediment mobilization and negligible change for shoreline exposure and sediment re-entrainment. Cumulative actions including Climate change with increased air and water temperatures may increase the likelihood of bloom formation. Adverse effects from RFFA's (section 4.2.2) may increase the potential growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Green Peter reservoir there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Foster reservoir would be negligible for shoreline exposure metric. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.4.3 McKenzie Subbasin*

Cougar downstream water temperatures would observe a negligible to minor beneficial effect as there is a water temperature control tower on site although cumulative actions including Climate change, water demands and mainstem flow targets may alter this effect.

A minor beneficial effect to TDG at Cougar although there are not TDG measures for Alternative 2B. Blue River is not expected to change as the RO's are utilized and TDG levels would not be expected to change.

Turbidity has the potential to increase as fine-grained sediment supply passing downstream of Cougar would observe a major change and Blue River would observe a moderate change.

A major change at Cougar and negligible change at Blue River in the potential head-of-reservoir sediment mobilization and major change in shoreline exposure may increase the potential for HAB growth. Sediment Re-entrainment has the potential for a moderate change at Cougar and major change for Blue River. A resuspension and scour of sediment may make nutrients available and facilitate algae bloom growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Cougar and Blue River reservoir there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.4.4 Middle Fork Willamette Subbasin*

There are no Water Temperature measures for the Middle Fork Willamette. Cumulative effects at Hills Creek and Lookout Point storing more water in the spring and increasing water surface elevations. Hills Creek would have a major adverse effect to water temperature targets in the summer which would mean an increase of the days of cooler (<18C or 64F) released downstream water temperatures. Downstream water temperatures at Dexter would have a negligible effect of downstream water temperatures as compared to the NAA.

TDG level effects would be negligible for Hills Creek, Lookout Point and Dexter as there are no TDG measures and has no reduction of days of TDG exceedances for the year (Appendix D Figure 2-35). Fall Creek reservoir does not have a TDG gage and effects would be similar to the NAA and Affected Environment.

Turbidity has the potential to increase as there is a moderate change of sediment supply in fine-grained sediments passing out of Hills Creek into the Middle Fork Willamette above Lookout Point. Dexter reservoir would have potential for minor change in fine grained sediment and negligible potential for change in sediment supply downstream of Dexter Dam.

HABs have the potential to increase as a major change in shoreline exposure is observed at Hills Creek and Lookout Point. Sediment Re-entrainment results in a major change for Hills Creek and minor change for Lookout Point. Fall Creek would observe negligible change and Dexter reservoir is a run-of-river project and is not included in these metrics. A resuspension of sediment may make nutrients available and facilitate algae bloom growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Hills Creek and Lookout Point reservoirs there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Fall Creek reservoir would see negligible change relative to the NAA. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.4.5 Coast Fork Willamette and Long Tom Subbasin*

There are no water temperature or TDG measures at Cottage Grove, Dorena or Fern Ridge as such conditions are expected to remain similar to the NAA. Negligible effects are expected for Turbidity, HABs and Mercury. Cumulative effects of RFFA's with adverse effects (section 4.2.2) to water quality may occur but it is unknown to what degree.

#### *4.5.2.4.6 Mainstem Willamette*

Mainstem Willamette at Albany and Salem water temperatures observes negligible effects to water temperature in the summer. A decrease of instream flows during conservation season, from late spring through early fall, along with cumulative actions of instream water withdrawals and Climate change may exacerbate water temperatures. Currently there are only summer water temperature targets for the Mainstem Willamette. Water quality parameters such as TDG, Turbidity, HABs are negligible or have not been reported as a concern. Cumulative effects of RFFA's with adverse effects (section 4.2.2) to water quality may occur but it is unknown to what degree.

#### *4.5.2.5 Alternative 3A – Operations-Focused Fish Passage Alternative*

Cumulative effects to water quality for Alternative 3A measures and RFFA's are described by Willamette Valley subbasins based on effects described in section 4.2.2. The summary of direct/indirect effects of Alternative 3A compared to the No Action Alternative are summarized in Table 3.5-22.

##### *4.5.2.5.1 North Santiam Subbasin*

Big Cliff downstream water temperatures would observe a major adverse effect of days below 18C (64.4F) during the summer which may be due to utilizing the spillway for surface spill in the summer at Detroit. A moderate adverse effect of days near temperature target from April through August which may be due to utilizing the spill way for surface spill in the summer at Detroit. A minor benefit for days near temperature target from September through March which may be due to use of the RO's discharging colder water during drawdown operations in the fall and winter to reduce water temperatures below Detroit. A measure to line the lower RO tunnels to limit cavitation effects and to assist in temperature control at Detroit may provide a benefit.

TDG measure included in Alternative 3A include an operation of spreading of water over the spillway in order to reduce TDG % exceedances at Detroit and Big Cliff. Major Adverse effects are observed at Detroit and Big Cliff for TDG levels as the annual difference in number of days above 110% TDG levels as compared to the NAA. This is likely due to an increase in utilizing the spillway for surface spill.

Turbidity has the potential to increase as there is a major change of fine-grained sediments passing into Big Cliff fun-of-reservoir and moderate change of the fine-grained sediments passing downstream into the North Santiam. Adverse effects from RFFA's (section 4.2.2) may increase the potential for Turbidity.

HABs have the potential to increase at Detroit Reservoir as there is a major change in head-of-reservoir, shoreline exposure and sediment re-entrainment. A resuspension of sediment may make nutrients available and facilitate algae bloom growth. Adverse effects from RFFA's (section 4.2.2) may increase the potential growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Detroit reservoir, which creates the potential for an increase in methylation due to water fluctuations. However, there are no foreseeable increases in anoxic waters. Big Cliff reservoir is a run-of river project that operates in a small range of pool elevations and is not included for the shoreline exposure metric. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.5.2 South Santiam Subbasin*

Foster observes negligible effects to downstream water temperatures with days below 18C (64.4F) during the summer which may be attributed to Green Peter and Foster spillway use for surface spill in the summer. Moderate beneficial effects to downstream water temperatures from April through August with the use of the Green Peter and Foster spillways for surface spill in the summer. Minor beneficial effect from September through March with the use the RO's to discharge colder water during fall and winter drawdown operations at Green Peter reservoir.

There are no measures for TDG abatement at Green Peter and Foster. Major adverse effects to TDG levels is observed at Green Peter and moderate adverse effect at Foster. A measure to use the spillway for surface spill in the summer at Green Peter and Foster may contribute to the increase of TDG levels.

Turbidity may increase as there is potential for major change of sediment supply in fine grained sediments entering Foster reservoir which may partially settle and may pass a moderate change of the fine-grained sediments downstream into the South Santiam. RFFA's with Adverse effects (section 4.2.2) and Climate change may increase Turbidity as winter precipitation is projected to increase which may increase sediment downstream of the dams.

HABs have the potential to increase as there is a major change for head-of-reservoir sediment mobilization, shoreline exposure and sediment re-entrainment at Green Peter reservoir. Foster reservoir has a minor change for potential head-of-reservoir sediment mobilization and negligible change for shoreline exposure and sediment re-entrainment. A resuspension of sediment may make nutrients available and facilitate algae bloom growth. Cumulative actions including Climate change with increased air and water temperatures may increase the likelihood of bloom formation. Adverse effects from RFFA's (section 4.2.2) may increase the potential growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Green Peter reservoir there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Foster reservoir would be negligible for shoreline exposure metric. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.5.3 McKenzie Subbasin*

Cougar downstream water temperatures would observe a negligible effect for days below 18C (64.4) in the summer, negligible effect for days near temperature target from April through

August, and minor adverse effect for days near temperature target from September through March. Cougar reservoir has a spring and fall drawdown which may limit ability to store water during conservation season. Blue River would store more water in the spring. Alternative 3A includes a measure to modify the spillway at Blue River dam to provide better water temperature management. Cumulative actions including Climate change, water demands and mainstem flow targets may alter water temperatures.

A negligible effect to TDG is observed at Cougar although as there are no TDG measures for Alternative 3A.

Turbidity has the potential to increase as fine-grained sediment supply passing downstream of Cougar and Blue River would observe a moderate change. RFFA's with Adverse effects (section 4.2.2) and Climate change may increase Turbidity as winter precipitation is projected to increase which may increase sediment downstream of the dams.

Cougar observes a major change and Blue River a minor change for potential head-of-reservoir sediment mobilization. A major change in shoreline exposure at Cougar and Blue River may increase the potential for HAB growth. Sediment Re-entrainment has the potential for a moderate change at Cougar and Blue River. A resuspension and scour of sediment may make nutrients available and facilitate algae bloom growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Cougar and Blue River reservoir there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.5.4 Middle Fork Willamette Subbasin*

Hills Creek would have a major adverse effect to water temperature targets in the summer which would mean an increase of the days of cooler (<18C or 64F) released downstream water temperatures. Beneficial effects are observed for Days near temperature targets for April through August and September through March at Hills Creek. Downstream water temperatures at Dexter would have a major adverse effect to water temperature targets in the summer with increase of the days of cooler released downstream water temperatures as compared to the NAA. Hills Creek will modify the spillway to use the spillway for surface spill in the summer.

TDG level effects would be negligible for Hills Creek and Lookout Point while Dexter would have minor adverse effects to TDG levels. A measure for spreading of spill across the dam for TDG management is included at Dexter. Fall Creek reservoir does not have a TDG gage and effects would be similar to the NAA and Affected Environment.

Turbidity has the potential to increase as there is a major change of sediment supply in fine-grained sediments into Dexter reservoir passing out of Lookout Point run-of-river reservoir.

Dexter reservoir would have potential for moderate change in fine grained sediment supply passing into the Middle Fork Willamette downstream of Dexter Dam.

HABs have the potential to increase with a minor change at Hills Creek and major change at Lookout Point for head-of-reservoir sediment mobilization relative to the NAA. A minor change at Hills Creek and major change at Lookout Point for shoreline exposure is observed. Sediment Re-entrainment results in a negligible effect for Hills Creek and major change for Lookout Point. Fall Creek would observe negligible change for head-of-reservoir, shoreline exposure and sediment re-entrainment metrics. A resuspension of sediment may make nutrients available and facilitate algae bloom growth.

Mercury has the potential to increase as there is a minor change in shoreline exposure compared to the NAA at Hills Creek and major change at Lookout Point reservoirs there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Fall Creek reservoir would see negligible change relative to the NAA. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

##### *4.5.2.5.5 Coast Fork Willamette and Long Tom Subbasin*

There are no water temperature or TDG measures at Cottage Grove, Dorena or Fern Ridge as such conditions are expected to remain similar to the NAA.

Turbidity has the potential to increase as there is a moderate change of sediment supply in fine-grained sediments passing into the Coast Fork Willamette and Row River from Cottage Grove dams.

HABs have the potential to increase with a major change for shoreline exposure and moderate change for sediment re-entrainment at Cottage Grove and Dorena dams. Fall creek would have a negligible change to the above metrics.

Mercury has the potential to increase with a major change to shoreline exposure which may affect the mercury methylation process at Cottage Grove and Dorena.

Cumulative effects of RFFA's with adverse effects (section 4.2.2) to water quality may occur but it is unknown to what degree.

##### *4.5.2.5.6 Mainstem Willamette*

Mainstem Willamette at Albany and Salem water temperatures observes minor adverse effects to water temperature in the summer. A decrease of instream flows during conservation season, from late spring through early fall, along with cumulative actions of instream water withdrawals and Climate change may exacerbate water temperatures. Currently there are only summer water temperature targets for the Mainstem Willamette. Water quality parameters such as

TDG, Turbidity, HABs are negligible or have not been reported as a concern. Cumulative effects of RFFA's with adverse effects (section 4.2.2) to water quality may occur but it is unknown to what degree.

#### *4.5.2.6 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)*

Cumulative effects to water quality for Alternative 3B measures and RFFA's are described by Willamette Valley subbasins based on effects described in section 4.2.2. The summary of direct/indirect effects of Alternative 3B compared to the No Action Alternative are summarized in Table 3.5-22.

##### *4.5.2.6.1 North Santiam Subbasin*

Big Cliff downstream water temperatures would observe negligible effects for all temperature targets. Measures include utilizing the spillway for surface spill in the summer at Detroit, lining of the lower RO tunnels to limit cavitation effects and to assist in temperature control at Detroit, utilizing the RO's to discharge cold water during drawdown operations in the fall and winter to reduce water temperatures below Detroit.

Alternative 3B includes a measure for operation of spreading of water over the spillway in order to reduce TDG % exceedances at Detroit and Big Cliff. Moderate Adverse effects are observed at Detroit and Big Cliff for TDG levels as the annual difference in number of days above 110% TDG levels as compared to the NAA. This is likely due to an increase in utilizing the spillway for surface spill.

Turbidity has the potential to increase as there is a moderate change of fine-grained sediments passing into Big Cliff fun-of-reservoir and minor change of the fine-grained sediments passing downstream into the North Santiam. Adverse effects from RFFA's (section 4.2.2) may increase the potential for Turbidity.

HABs have the potential to increase at Detroit Reservoir as there is a major change in head-of-reservoir, shoreline exposure and sediment re-entrainment. A resuspension of sediment may make nutrients available and facilitate algae bloom growth. Adverse effects from RFFA's (section 4.2.2) may increase the potential growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Detroit reservoir, which creates the potential for an increase in methylation due to water fluctuations. However, there are no foreseeable increases in anoxic waters. Big Cliff reservoir is a run-of river project that operates in a small range of pool elevations and is not included for the shoreline exposure metric. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.6.2 South Santiam Subbasin*

Foster observes major adverse effects to downstream water temperatures with days below 18C (64.4F) during the summer. Moderate beneficial effects to downstream water temperatures from April through August with the use of the Green Peter and Foster spillways for surface spill in the summer. Negligible effect from September through March with the use the RO's to discharge colder water during fall and winter drawdown operations at Green Peter reservoir.

Alternative 3B measure for TDG abatement is observed at Foster reservoir with spreading of spill. Green Peter has no TDG measure. Both reservoirs observe a minor adverse effect.

Turbidity may increase as there is potential for major change of sediment supply in fine grained sediments entering Foster reservoir which may partially settle and may pass a moderate change of the fine-grained sediments downstream into the South Santiam. RFFA's with Adverse effects (section 4.2.2) and Climate change may increase Turbidity as winter precipitation is projected to increase which may increase sediment downstream of the dams.

HABs have the potential to increase as there is a major change for head-of-reservoir sediment mobilization, shoreline exposure and sediment re-entrainment at Green Peter reservoir. Foster reservoir has a minor change for potential head-of-reservoir sediment mobilization and negligible change for shoreline exposure and sediment re-entrainment. A resuspension of sediment may make nutrients available and facilitate algae bloom growth. Cumulative actions including Climate change with increased air and water temperatures may increase the likelihood of bloom formation. Adverse effects from RFFA's (section 4.2.2) may increase the potential growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Green Peter reservoir there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Foster reservoir would be negligible for shoreline exposure metric. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.6.3 McKenzie Subbasin*

Cougar downstream water temperatures would observe a negligible effect for days below 18C (64.4) in the summer, minor benefit for days near temperature target from April through August, and minor benefit effect for days near temperature target from September through March. Cougar reservoir includes a measure within Alternative 3B to modify a diversion tunnel for water temperature control. Blue River reservoir includes measures to modify the spillway for better water temperature management and use of the spillway in the summer for surface spill. Cumulative actions including Climate change, water demands and mainstem flow targets may alter water temperatures.

A minor beneficial effect to TDG is observed at Cougar although there are no TDG measures for Alternative 3B.

Turbidity has the potential to increase as fine-grained sediment supply passing downstream of Cougar and Blue River would observe a major and moderate change. RFFA's with Adverse effects (section 4.2.2) and Climate change may increase Turbidity as winter precipitation is projected to increase which may increase sediment downstream of the dams.

Cougar observes a major change and Blue River a minor change for potential head-of-reservoir sediment mobilization. A major change in shoreline exposure at Cougar and Blue River may increase the potential for HAB growth. Sediment Re-entrainment has the potential for a major and moderate change at Cougar and Blue River. A resuspension and scour of sediment may make nutrients available and facilitate algae bloom growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Cougar and Blue River reservoir there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

##### *4.5.2.6.4 Middle Fork Willamette Subbasin*

Hills Creek would have a major adverse effect to water temperature targets in the summer which would mean an increase of the days of cooler (<18C or 64F) released downstream water temperatures. Moderate beneficial effects are observed for Days near temperature targets for April through August and September through March at Hills Creek. A negligible effect for days near temperature target from September through March is observed at Hills Creek. Downstream water temperatures at Dexter would have a minor adverse effect to water temperature targets in the summer with increase of the days of cooler released downstream water temperatures as compared to the NAA. Dexter downstream water would observe a moderate benefit for days near temperature target from April through August and negligible effect for days near temperature target from September through March. Hills Creek will modify the spillway to use the spillway for surface spill in the summer.

TDG level effects would be negligible for Hills Creek and Lookout Point while Dexter would have minor adverse effects to TDG levels. A measure for spreading of spill across the dam for TDG management is included at Lookout Point and Dexter. Fall Creek reservoir does not have a TDG gage and effects would be similar to the NAA and Affected Environment.

Turbidity has the potential to increase as there is a major change of sediment supply in fine-grained sediments into Dexter reservoir passing out of Lookout Point run-of-river reservoir. Dexter reservoir would have potential for moderate change in fine grained sediment supply passing into the Middle Fork Willamette downstream of Dexter Dam.

HABs have the potential to increase with a major change at Hills Creek and Lookout Point for head-of-reservoir sediment mobilization relative to the NAA. A major change at Hills Creek and major change at Lookout Point for shoreline exposure is observed. Sediment Re-entrainment results in a negligible effect for Hills Creek and major change for Lookout Point. Fall Creek would observe negligible change for head-of-reservoir, shoreline exposure and sediment re-entrainment metrics. A resuspension of sediment may make nutrients available and facilitate algae bloom growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Hills Creek and Lookout Point reservoirs there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Fall Creek reservoir would see negligible change relative to the NAA. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

##### *4.5.2.6.5 Coast Fork Willamette and Long Tom Subbasin*

There are no water temperature or TDG measures at Cottage Grove, Dorena or Fern Ridge as such conditions are expected to remain similar to the NAA.

Turbidity has the potential to increase as there is a moderate change of sediment supply in fine-grained sediments as compared to the NAA passing into the Coast Fork Willamette and Row River from Cottage Grove dams. There is negligible change in sediment supply relative to the NAA in the Long Tom River.

HABs have the potential to increase with a major change for shoreline exposure as compared to the NAA and moderate change for sediment re-entrainment at Cottage Grove and Dorena dams. Fern Ridge would have a negligible change to the above metrics.

Mercury has the potential to increase with a major change to shoreline exposure as compared to the NAA which may affect the mercury methylation process at Cottage Grove and Dorena.

Cumulative effects of RFFA's with adverse effects (section 4.2.2) to water quality may occur but it is unknown to what degree.

##### *4.5.2.6.6 Mainstem Willamette*

Mainstem Willamette at Albany and Salem water temperatures observe negligible effects to water temperature in the summer. A decrease of instream flows during conservation season, from late spring through early fall, along with cumulative actions of instream water withdrawals and Climate change may exacerbate water temperatures. Currently there are only summer water temperature targets for the Mainstem Willamette. Water quality parameters such as TDG, Turbidity, HABs are negligible or have not been reported as a concern. Cumulative effects of RFFA's with adverse effects (section 4.2.2) to water quality may occur but it is unknown to what degree.

### 4.5.2.7 Alternative 4 – Structures-Based Fish Passage Alternative

Cumulative effects to water quality for Alternative 4 measures and RFFA's are described by Willamette Valley subbasins based on effects described in section 4.2.2. The summary of direct/indirect effects of Alternative 4 compared to the No Action Alternative are summarized in Table 3.5-25.

#### *4.5.2.7.1 North Santiam Subbasin*

Big Cliff downstream water temperatures would observe negligible effects for days below 18C (64.4F; summer) temperature targets as compared to the NAA. A moderate benefit for days near temperature target from April through August, and major benefit for days near temperature target from September through March. The inclusion of a water temperature control at Detroit reservoir may provide the beneficial effect that is observed.

Alternative 4 includes a measure for TDG structural improvement in the design of the Detroit water temperature control tower which results in a moderate beneficial effect. Big Cliff includes a measure for structural improvement to reduce TDG and mechanical degassing at the adult fish facility which results in a major beneficial effect.

Turbidity has the potential to increase as there is a moderate change of fine-grained sediments passing into Big Cliff fun-of-reservoir and minor change of the fine-grained sediments passing downstream into the North Santiam. Adverse effects from RFFA's (section 4.2.2) may increase the potential for Turbidity.

HABs have the potential to increase at Detroit Reservoir as there is a negligible change in head-of-reservoir, major change for shoreline exposure and major change for sediment re-entrainment. A resuspension of sediment may make nutrients available and facilitate algae bloom growth. Adverse effects from RFFA's (section 4.2.2) may increase the potential growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Detroit reservoir, which creates the potential for an increase in methylation due to water fluctuations. However, there are no foreseeable increases in anoxic waters. Big Cliff reservoir is a run-of river project that operates in a small range of pool elevations and is not included for the shoreline exposure metric. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.7.2 South Santiam Subbasin*

Foster observes major beneficial effects to downstream water temperatures with days below 18C (64.4F) during the summer as compared to the NAA. Minor beneficial effects to downstream water temperatures from April through August with the use of the Green Peter spillways for surface spill in the summer. Negligible effect from September through March with the use the RO's to discharge colder water during fall and winter drawdown operations at Green Peter reservoir.

Alternative 4 measure for TDG abatement is a structural improvement at the Foster adult fish collection facility. Foster observes a negligible effect. There are no TDG abatement measure at Green Peter and a major adverse effect is observed.

Turbidity may increase as there is potential for moderate change of sediment supply in fine grained sediments as compared to the NAA entering Foster reservoir which may partially settle and may pass a minor change of the fine-grained sediments downstream into the South Santiam. RFFA's with Adverse effects (section 4.2.2) and Climate change may increase Turbidity as winter precipitation is projected to increase which may increase sediment downstream of the dams.

HABs have the potential to increase as there is a negligible change for head-of-reservoir sediment mobilization at Green Peter and Foster. Green Peter reservoir observes in a major change for shoreline exposure and sediment re-entrainment as compared to the NAA. Foster reservoir has a negligible change for sediment mobilization, shoreline exposure and sediment re-entrainment. A resuspension of sediment may make nutrients available and facilitate algae bloom growth. Cumulative actions including Climate change with increased air and water temperatures may increase the likelihood of bloom formation. Adverse effects from RFFA's (section 4.2.2) may increase the potential growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Green Peter reservoir there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Foster reservoir would be negligible for shoreline exposure metric. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

##### *4.5.2.7.3 McKenzie Subbasin*

Cougar downstream water temperatures observes negligible effects as there no water temperature measures within Alternative 4. Cumulative actions including Climate change, water demands and mainstem flow targets may alter water temperatures.

A minor beneficial effect to TDG is observed at Cougar with the inclusion of structural improvement measure for TDG within Alternative 4.

Turbidity has the potential to increase as fine-grained sediment supply passing downstream of Cougar and Blue River would observe a minor and moderate change. RFFA's with Adverse effects (section 4.2.2) and Climate change may increase Turbidity as winter precipitation is projected to increase which may increase sediment downstream of the dams.

A major change at Cougar and negligible change at Cougar and Blue River in the potential head-of-reservoir sediment mobilization. A major change in shoreline exposure at Cougar and Blue River may increase the potential for HAB growth. Sediment Re-entrainment has the potential for a moderate change at Cougar and major change at Blue River. A resuspension and scour of sediment may make nutrients available and facilitate algae bloom growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Cougar and Blue River reservoir there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.7.4 Middle Fork Willamette Subbasin*

Hills Creek would have a major adverse effect to water temperature targets in the summer which would mean an increase of the days of cooler (<18C or 64F) released downstream water temperatures. Major beneficial effects are observed for Days near temperature targets for April through August and moderate benefit during September through March at Hills Creek. The effects observed at Hills Creek may be due to the inclusion of a water temperature control tower to better regulate downstream water temperatures. Downstream water temperatures at Dexter would have a major adverse effect to water temperature targets in the summer with increase of the days of cooler released downstream water temperatures as compared to the NAA. Dexter downstream water would observe a negligible effect for days near temperature target from April through August and September through March. Dexter has no TDG measures included in Alternative 4 although a water temperature control tower is included at Lookout Point. There are no water temperature measures for Fall Creek.

TDG level effects would be negligible for Hills Creek, Lookout Point and Dexter. Alternative 4 includes a measure for a water temperature control tower at Lookout Point. Dexter Reservoir includes a structural improvement to reduce TDG and mechanical degassing method in the fish collection and hatchery area downstream of the dam. Fall Creek reservoir does not have a TDG gage and effects would be similar to the NAA and Affected Environment.

Turbidity has the potential to increase as there is a moderate change of sediment supply in fine-grained sediments into Hills Creek reservoir. A minor change in fine-grained sediment supply to the Dexter run-of-river reservoir.

All Middle Fork Willamette dams have a negligible change for head-of-reservoir sediment mobilization relative to the NAA. A major change at Hills Creek and Lookout Point for shoreline exposure is observed. Sediment Re-entrainment results in a major effect for Hills Creek and minor change for Lookout Point. Fall Creek would observe negligible change for head-of-reservoir, shoreline exposure and sediment re-entrainment metrics. A resuspension of sediment may make nutrients available and facilitate algae bloom growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Hills Creek and Lookout Point reservoirs there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Fall Creek reservoir would see negligible change relative to the NAA. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

##### *4.5.2.7.5 Coast Fork Willamette and Long Tom Subbasin*

There are no water temperature or TDG measures at Cottage Grove, Dorena or Fern Ridge as such conditions are expected to remain similar to the NAA.

Turbidity has the potential to increase as there is a moderate change of sediment supply in fine-grained sediments passing into the Coast Fork Willamette and Row River from Cottage Grove dams. There is negligible change in sediment supply relative to the NAA in the Long Tom River free-flowing reach.

A Negligible change to potential for head-of-reservoir sediment mobilization is observed at all WVS storage projects. HABs have the potential to increase with a major change for shoreline exposure at Cottage Grove and Dorena reservoirs. A moderate change for sediment re-entrainment at Cottage Grove and Dorena dams. Fern Ridge would have a negligible change to the above metrics.

A major change to shoreline exposure relative to the NAA is observed at Cottage Grove and Dorena. Fern Ridge results in negligible change. Exposed sediment may affect the mercury methylation process at Cottage Grove and Dorena.

Cumulative effects of RFFA’s with adverse effects (section 4.2.2) to water quality may occur but it is unknown to what degree.

##### *4.5.2.7.6 Mainstem Willamette*

Mainstem Willamette at Albany observe negligible effects to water temperature in the summer, while Salem observes minor adverse effects relative to the NAA. A decrease of instream flows during conservation season, from late spring through early fall, along with cumulative actions of instream water withdrawals and Climate change may exacerbate water temperatures. Currently there are only summer water temperature targets for the Mainstem Willamette. Water quality parameters such as TDG, Turbidity, HABs are negligible or have not been reported as a concern. Cumulative effects of RFFA’s with adverse effects (section 4.2.2) to water quality may occur but it is unknown to what degree.

### *4.5.2.8 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Cumulative effects to water quality for Alternative 4 measures and RFFA's are described by Willamette Valley subbasins based on effects described in section 4.2.2. The summary of direct/indirect effects of Alternative 5 compared to the No Action Alternative are summarized in Table 3.5-28.

#### *4.5.2.8.1 North Santiam Subbasin*

Big Cliff downstream water temperatures observes a negligible effect of days below 18C (64.4F) during the summer and moderate benefit of days near temperature target from April through August and major benefit for days near temperature target from September through March with the inclusion of a Water Temperature Control tower at Detroit dam.

No TDG measures are included in Alternative 2B although a moderate benefit is observed at Detroit and Big Cliff for TDG levels as the annual difference in number of days above 110% TDG levels is less as compared to the NAA.

Turbidity has the potential to increase as there is a moderate change downstream of Detroit Dam in fine grained sediments entering Big Cliff reservoir and minor change of the fine-grained sediments passing downstream into the North Santiam. Adverse effects from RFFA's (section 4.2.2) may increase the potential for Turbidity.

HABs have the potential to increase at Detroit Reservoir as there is a major change in shoreline exposure and sediment re-entrainment. A resuspension of sediment may make nutrients available and facilitate algae bloom growth. Adverse effects from RFFA's (section 4.2.2) may increase the potential growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Detroit reservoir, which creates the potential for an increase in methylation due to water fluctuations. However, there are no foreseeable increases in anoxic waters. Big Cliff reservoir is a run-of river project that operates in a small range of pool elevations and is not included for the shoreline exposure metric. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.8.2 South Santiam Subbasin*

Foster observes negligible effects to downstream water temperatures with days below 18C (64.4F) during the summer with the use of the spillway for surface spill in the summer at Green Peter reservoir. Moderate beneficial effects to downstream water temperatures from April through August which may be due to the modifications to increase warm water releases through a Foster Warm Water Supply (FWWS) pipe and fish weir at Foster Dam. A minor beneficial effect from September through March may be due to the use the RO's discharge of colder water during fall and winter drawdown operations at Green Peter reservoir.

There are no measures for TDG abatement at Green Peter and Foster. Major adverse effects to TDG levels are observed at Green Peter and moderate adverse effect at Foster reservoirs which may be due to the increase of spill as compared to the NAA. A measure to use the spillway for surface spill in the summer at Green Peter may contribute to the increase of TDG levels.

Turbidity has the potential to increase as there is potential for major change of sediment supply in fine grained sediments entering Foster reservoir which may partially settle and may pass a moderate change of the fine-grained sediments downstream into the South Santiam. RFFA's with Adverse effects (section 4.2.2) and Climate change may increase Turbidity as winter precipitation is projected to increase this may increase sediment downstream of the dams.

HABs have the potential to increase as there is a major change for head-of-reservoir sediment mobilization, shoreline exposure and sediment re-entrainment at Green Peter reservoir. A resuspension of sediment may make nutrients available and facilitate algae bloom growth. Foster reservoir has a minor change for potential head-of-reservoir sediment mobilization and negligible change for shoreline exposure and sediment re-entrainment. Cumulative actions including Climate change with increased air and water temperatures may increase the likelihood of bloom formation. Adverse effects from RFFA's (section 4.2.2) may increase the potential growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Green Peter reservoir there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Foster reservoir would be negligible for shoreline exposure metric. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.8.3 McKenzie Subbasin*

Cougar downstream water temperatures would observe a negligible to minor beneficial effect as there is a water temperature control tower on site although cumulative actions including Climate change, water demands and mainstem flow targets may alter this effect.

A minor beneficial effect to TDG at Cougar although there are not TDG measures for Alternative 2B. Blue River is not expected to change as the RO's are utilized and TDG levels would not be expected to change.

Turbidity has the potential to increase as fine-grained sediment supply passing downstream of Cougar would observe a major change and Blue River would observe a moderate change.

A major change at Cougar and negligible change at Blue River in the potential head-of-reservoir sediment mobilization and major change in shoreline exposure may increase the potential for

HAB growth. Sediment Re-entrainment has the potential for a moderate change at Cougar and major change for Blue River. A resuspension and scour of sediment may make nutrients available and facilitate algae bloom growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Cougar and Blue River reservoir there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.8.4 Middle Fork Willamette Subbasin*

There are no Water Temperature measures for the Middle Fork Willamette. Cumulative effects at Hills Creek and Lookout Point storing more water in the spring and increasing water surface elevations. Hills Creek would have a major adverse effect to water temperature targets in the summer which would mean an increase of the days of cooler (<18C or 64F) released downstream water temperatures. Downstream water temperatures at Dexter would have a negligible effect of downstream water temperatures as compared to the NAA.

TDG level effects would be negligible for Hills Creek, Lookout Point and Dexter as there are no TDG measures and has no reduction of days of TDG exceedances for the year (Appendix D, Figure 2-35). Fall Creek reservoir does not have a TDG gage and effects would be similar to the NAA and Affected Environment.

Turbidity has the potential to increase as there is a moderate change of sediment supply in fine-grained sediments passing out of Hills Creek into the Middle Fork Willamette above Lookout Point. Dexter reservoir would have potential for minor change in fine grained sediment and negligible potential for change in sediment supply downstream of Dexter Dam.

HABs have the potential to increase as a major change in shoreline exposure is observed at Hills Creek and Lookout Point. Sediment Re-entrainment results in a major change for Hills Creek and minor change for Lookout Point. Fall Creek would observe negligible change and Dexter reservoir is a run-of-river project and is not included in these metrics. A resuspension of sediment may make nutrients available and facilitate algae bloom growth.

Mercury has the potential to increase as there is a major change in shoreline exposure compared to the NAA at Hills Creek and Lookout Point reservoirs there is potential for an increase for the methylation process to occur with water fluctuations. However, there are no foreseeable increases in anoxic waters. Fall Creek reservoir would see negligible change relative to the NAA. Cumulative actions including Climate Change with increased air and water temperatures and precipitation events may increase the likelihood of mercury.

#### *4.5.2.8.5 Coast Fork Willamette and Long Tom Subbasin*

There are no water temperature or TDG measures at Cottage Grove, Dorena or Fern Ridge as such conditions are expected to remain similar to the NAA. Negligible effects are expected for Turbidity, HABs and Mercury. Cumulative effects of RFFA's with adverse effects (section 4.2.2) to water quality may occur but it is unknown to what degree.

#### *4.5.2.8.6 Mainstem Willamette*

Mainstem Willamette at Albany and Salem water temperatures observes negligible effects to water temperature in the summer. A decrease of instream flows during conservation season, from late spring through early fall, along with cumulative actions of instream water withdrawals and Climate change may exacerbate water temperatures. Currently there are only summer water temperature targets for the Mainstem Willamette. Water quality parameters such as TDG, Turbidity, HABs are negligible or have not been reported as a concern. Cumulative effects of RFFA's with adverse effects (section 4.2.2) to water quality may occur but it is unknown to what degree.

# 4.6 VEGETATION

## 4.6.1 Cumulative Effects Analysis Methodology for Vegetation

### *4.6.1.1 Cumulative Actions Applicable to Vegetation*

Past, present, and RFFAs that, when considered together with the Proposed Action and alternatives, would have cumulative effects on vegetation include:

- WVS Dams and Reservoirs: construction and past operations and maintenance (see section 4.2.1.1) as well as ongoing operations and maintenance (see section 4.2.2)
- WRB Population Growth and Development: increased development extent and intensity within the Willamette River Basin (see section 4.2.1.2)
- RFFA 1: Future population growth and accompanying urban, industrial, and commercial development
- RFFA 2: Future agricultural development
- RFFA 3: Water withdrawals for municipal, industrial, and agricultural uses
- RFFA 4: Decarbonizing the energy sector with renewable energy sources
- RFFA 5: Federal and state wildlife and lands management
- RFFA 7: Tribal, state, and local fish and wildlife improvement
- RFFA 8: Invasive species management
- RFFA 9: Climate change
- RFFA 11: Timber and logging industry operations

Some of the other RFFAs discussed in Section 4.2.3 would not change the vegetative communities of the Willamette Basin or any changes would be negligible. These include:

- RFFA 6: Fishery management and killer whales. Because flows would not have more than a negligible effect as a result of this RFFA, vegetation would not be affected.
- RFFA 10: Mining operations. Mining operations have a negligible effect on vegetation.

Therefore, these RFFAs are dismissed from further analysis.

## 4.6.2 Cumulative Effects to Vegetation by Alternative

The WVS dams and reservoirs are currently authorized for flood control, hydropower, pollution abatement, fish and wildlife conservation, recreation, irrigation, municipal and industrial water supply, and water quality. Vegetative communities within the WRB have been changed from the natural condition by the construction and operation of the WVS dams and reservoirs, dams constructed by other entities (Section 4.1.2.1.1), urban and rural development and land use, transportation infrastructure development, logging operations within the watershed, and proliferation of invasive plant species as a result of much of this development. The cumulative effect is the conversion of complex stream reaches with a variety of habitats that support a variety of vegetative communities to inland lakes (reservoirs) and simplification of the regulated river reaches that provide less overbank flows and hydrology for streamside vegetative communities. In addition, certain invasive plants have proliferated in these hydrologic conditions such that species such as reed canarygrass now form dense monocultures in some areas, preventing a more diverse native vegetative community from establishing in these areas.

Future population growth and accompanying urban, industrial, and commercial development (RFFA 1) occurring in the WRB would continue to affect vegetation by further disturbing native vegetative communities during construction activities and would continue to introduce non-native invasive plant species that establish quickly after ground-disturbing activities. Development related to decarbonizing the energy sector with renewable energy sources (RFFA 4) such as wind and solar projects would affect vegetation similarly. There are construction standards in regard to preserving native vegetation and re-establishing vegetative communities following construction; however, this guidance and the implementation of this guidance varies by project type and the agency undertaking the project. Therefore, the cumulative actions associated with this development would create adverse, additive, and moderate effects to vegetation.

Future agricultural development (RFFA 2) occurring in historical floodplains would further limit a native diverse vegetative community in these areas. Outside of the urban growth boundaries within the WRB, this floodplain development would likely be in the form of larger ranchettes or properties that take advantage of the hydrology in soils within low-lying areas. Typically, agricultural operations that are growing crops use land that otherwise would support a native plant community and instead work to establish a monoculture of non-native plants. Some of the plants associated with these agricultural areas are also invasive and would spread into riparian and aquatic areas. In addition, agricultural development with livestock may further spread invasive plants into the watershed through the movement of the animals within riparian and floodplain areas. The cumulative actions associated with agricultural development would create adverse, additive, and minor effects to vegetation.

Water withdrawals for municipal, industrial, and agricultural uses (RFFA 3) would have the effect of either decreasing reservoir water surface elevation, decreasing instream flows, or a combination of both. Decreased water surface elevation would decrease the extent of soil saturation in proximity to reservoirs and WVS stream reaches, which would change the vegetative communities in these areas. More drought-tolerant species would become dominant and wetland and riparian vegetation that depend on greater soil saturation would become less dominant. These cumulative actions would create adverse, additive, and moderate effects to vegetation. These effects to vegetation have largely been considered in Section 3.6 as they relate to the hydrologic effects for each alternative.

Federal and state wildlife and lands management (RFFA 5) and timber and logging industry operations (RFFA 11) happen throughout the regulated and unregulated portions of the watershed and are conservation focused or expected to occur with similar actions and rates as in the recent past. National forests, wilderness areas, and wildlife refuges (listed in Section 4.2.6) management actions, including vegetation management actions, will continue as currently undertaken. Rates of herbicide application to control invasive plants, timber harvest, and tree replanting associated with logging operations would continue at rates similar to current operations. The cumulative actions would be additive and cause moderate effects to vegetation.

Tribal, state, and local fish and wildlife improvement (RFFA 7) includes river and floodplain restoration actions and potentially environmental flows to inundate floodplain areas. Environmental flows have been performed historically in the Willamette system but have been limited in magnitude to non-damaging peak flows similar to smaller regulated flood events. The floodplain restoration actions would likely include some amount of native plant preservation, invasive plant removal, and native species planting efforts. These cumulative actions would create beneficial, additive, and minor effects to vegetation within the WRB.

Invasive species management (RFFA 8) includes a range of vegetation management actions (e.g., herbicide application, mowing, controlled burns, etc.) taken by federal, state, and local agencies as well as private organizations to combat the spread of invasive plant species (see section 3.6.1.3.1 for more information). Vegetation management within the WRB would likely continue at the same rate as it currently is undertaken. These actions would create beneficial, additive, and moderate effects to vegetation within the WRB.

Climate change (RFFA 9) would change the composition of the vegetative communities within the WRB through overall drier conditions, which would affect plants in riparian areas and around the reservoirs. In addition, increased wildfires throughout the WRB would also change the composition of vegetative communities. See the climate change sections of each alternative in section 3.6 for more information. Ultimately, climate change effects would be adverse, additive, and have moderate effects to vegetation within the WRB.

In general, the RFFAs have an adverse, additive, moderate effect on vegetation throughout the WRB. Continued development throughout the basin and all the actions associated with increased population within both urban and rural areas as well as other RFFA's that cause additional stress on vegetation (e.g., water withdrawals, invasive plant proliferation, and climate change) would impact vegetative communities by changing species composition to a more drought tolerant vegetative community with less biodiversity. However, vegetative communities would continue to be improved or maintained by benefits such as restoration actions within the floodplains and management of invasive plant species. General trends described in this section apply to all subbasins within the WVS. Differences in the cumulative effects per subbasin will be described in the discussion below.

#### *4.6.2.1 No Action Alternative*

Combined with the effects of the cumulative effects listed above (particularly climate change), there would likely be additional effects to vegetation under the No Action Alternative. As discussed in section 3.6.3.1, the effects of the No Action Alternative would have both a beneficial and an adverse effect to vegetative communities in the WVS. The beneficial effect of the NAA is that water storage in the reservoirs would be maintained and would continue to support a vegetative community around the reservoirs that may not otherwise exist. The adverse effect is that streamside vegetative communities along reaches downstream of the USACE projects would continue to rely primarily on precipitation since stream flows would continue to be managed for flood control, limiting water uptake for vegetative communities across the floodplain. Therefore, combined with climate change, there would be changes in vegetative communities within the WVS due to hotter drier summers and a higher frequency of wildfires. It should be noted that the NAA will have negligible to minor effects (both beneficial and adverse) to the overall cumulative effects as it would maintain existing conditions.

#### *4.6.2.2 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Overall, cumulative effects to vegetation would be anticipated to be moderate and adverse over the period of analysis. However, Alternative 1 would not contribute substantially to the changes in the vegetative communities of the WVS. Changes to the vegetative community in terms of species composition would be affected to a greater magnitude by climate change, water withdrawals, federal and state wildlife and lands management, and invasive species management than by Alternative 1. Cumulative effect summaries for Alternative 1 by subbasin are provided below.

##### *4.6.2.2.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Santiam subbasin entails a species composition dominated by drought-tolerant plants and a growing population of the more resilient invasive plants that thrive in disturbed areas, which would have a moderate effect to vegetation within the subbasin.

With the implementation of Alternative 1, gravel augmentation downstream of Big Cliff and Foster Dams will slightly improve conditions for vegetative communities along downstream reaches within the Santiam subbasin. On the other hand, the drawdowns within Green Peter and Detroit will further exacerbate the cumulative effects thereby increasing trends toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

#### *4.6.2.2.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Long Tom subbasin would entail a species composition with increasing numbers of drought-tolerant and invasive plants and this would constitute a moderate effect within the Long Tom subbasin. Alternative 1 would not change operations at Fern Ridge and therefore would not affect changes within the subbasin.

#### *4.6.2.2.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of vegetative communities in the McKenzie subbasin would entail a species composition dominated by drought-tolerant invasive plants along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs.

With the implementation of Alternative 1, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for vegetative communities along downstream reaches within the McKenzie subbasin. On the other hand, the drawdowns at Cougar reservoir would make vegetation around the reservoirs more susceptible to climate change effects and will push trends toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs. Ultimately, minor adverse effects to vegetation would be anticipated around Cougar reservoir.

#### *4.6.2.2.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Falls Creek, Hills Creek, and Lookout Point, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Middle Fork Willamette subbasin entails a species composition dominated by drought-tolerant plants and a growing population of the more resilient invasive plants that thrive in disturbed areas. These cumulative effects would constitute a moderate effect to vegetation within the subbasin primarily because of climate change.

With the implementation of Alternative 1, gravel augmentation downstream of the WVS dams will slightly improve conditions for vegetative communities along downstream reaches within the Middle Fork Willamette subbasin. On the other hand, the drawdowns at Falls Creek, Hills Creek, and Lookout Point reservoirs will further exacerbate the cumulative effects thereby increasing trends toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs, which would be considered a moderate effect to vegetation.

##### *4.6.2.2.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Coast Fork Willamette subbasin entails a species composition dominated by drought-tolerant plants including the more resilient invasive plants that thrive in disturbed areas.

With the implementation of Alternative 1, increased storage at Cottage Grove and Dorena would offset lower reservoir elevations anticipated as a result of cumulative effects during conservation season; however, the drawdowns within Cottage Grove and Dorena will further exacerbate the cumulative effects thereby increasing trends toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs, an adverse moderate effect.

##### *4.6.2.2.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 1 would not have a more than negligible effect on the general trend of vegetative communities along the Mainstem Willamette River becoming more dominated by drought-tolerant and invasive plants.

#### ***4.6.2.3 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (includes structural downstream passage at Cougar Dam)***

Overall, cumulative effects to vegetation would be moderate over the period of analysis. Changes to the vegetative community in terms of species composition would be affected by climate change, water withdrawals, federal and state wildlife and lands management, and invasive species management. Alternative 2A would also have moderate effects to the vegetative communities of the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in some subbasins as discussed below.

##### *4.6.2.3.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Santiam subbasin entails a species composition dominated by drought-tolerant plants and a growing population of the more resilient invasive plants that thrive in disturbed areas, which would have a moderate effect to vegetation within the subbasin.

With the implementation of Alternative 2A, gravel augmentation downstream of Big Cliff and Foster Dams will slightly improve conditions for vegetative communities along downstream reaches within the Santiam subbasin. On the other hand, the drawdowns within Green Peter and Detroit will further exacerbate the cumulative effects. Particularly at Green Peter, where a deep fall drawdown would be implemented, there would be potential for major effects to vegetation when combined with cumulative effects, particularly climate change. This effect would entail an increasing trend toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

##### *4.6.2.3.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Long Tom subbasin would entail a species composition with increasing numbers of drought-tolerant and invasive plants and this would constitute a moderate effect within the Long Tom subbasin. Alternative 2A would not change operations at Fern Ridge and therefore would not affect changes within the subbasin.

##### *4.6.2.3.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of vegetative communities in the McKenzie subbasin would entail a species composition with increasing populations of drought-tolerant and invasive plants along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 2A, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for vegetative communities along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make vegetation around the reservoirs more susceptible to climate change effects, which would constitute a minor effect, pushing trends toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

##### *4.6.2.3.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of vegetative communities in the Middle Fork Willamette subbasin would entail a species composition with increasing populations of drought-tolerant and invasive plants along downstream reaches due to climate change but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 2A, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for vegetative communities along downstream reaches within the Middle Fork Willamette subbasin. On the other hand, the drawdowns within Hills Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects. There would be potential for moderate effects to vegetation around the reservoirs as a result of the drawdowns combined with cumulative effects, particularly climate change. This effect would entail an increasing trend toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

##### *4.6.2.3.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Coast Fork Willamette subbasin entails a species composition dominated by drought-tolerant plants including the more resilient invasive plants that thrive in disturbed areas.

The implementation of Alternative 2A would not have a more than negligible effect on the general trend of vegetative communities along the Coast Fork Willamette River becoming more dominated by drought-tolerant and invasive plants.

##### *4.6.2.3.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 2A would not have a more than negligible effect on the general trend of vegetative communities along the Mainstem Willamette River becoming more dominated by drought-tolerant and invasive plants.

#### ***4.6.2.4 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative***

Overall, cumulative effects to vegetation would be moderate over the period of analysis. Changes to the vegetative community in terms of species composition would be affected by climate change, water withdrawals, federal and state wildlife and lands management, and invasive species management. Alternative 2B would also have moderate effects to the vegetative communities of the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in some subbasins as discussed below. Most notably at Cougar reservoir, because deep fall and spring drawdowns would be included as a part of Alternative 2B (as opposed to Alternative 2A) there would be potential for major effects to vegetation around the reservoir when combined with climate change effects.

##### *4.6.2.4.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Santiam subbasin entails a species composition dominated by drought-tolerant plants and a growing population of the more resilient invasive plants that thrive in disturbed areas, which would have a moderate effect to vegetation within the subbasin.

With the implementation of Alternative 2B, gravel augmentation downstream of Big Cliff and Foster Dams will slightly improve conditions for vegetative communities along downstream reaches within the Santiam subbasin. On the other hand, the drawdowns within Green Peter and Detroit will further exacerbate the cumulative effects. Particularly at Green Peter, where a deep fall drawdown would be implemented, there would be potential for major effects to vegetation when combined with cumulative effects, particularly climate change. This effect would entail an increasing trend toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

##### *4.6.2.4.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Long Tom subbasin would entail a species composition with increasing numbers of drought-tolerant and invasive plants and this would constitute a moderate effect within the Long Tom subbasin. Alternative 2B would not change operations at Fern Ridge and therefore would not affect changes within the subbasin.

##### *4.6.2.4.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of vegetative communities in the McKenzie subbasin would entail a species composition with increasing populations of drought-tolerant and invasive plants along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 2B, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for vegetative communities along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make vegetation around the reservoirs more susceptible to climate change effects. Particularly at Cougar, where deep fall and spring drawdowns would be implemented, there would be potential for moderate effects to vegetation when combined with cumulative effects, particularly climate change. This would push trends toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

##### *4.6.2.4.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of vegetative communities in the Middle Fork Willamette subbasin would entail a species composition with increasing populations of drought-tolerant and invasive plants along downstream reaches due to climate change but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 2B, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for vegetative communities along downstream reaches within the Middle Fork Willamette subbasin. On the other hand, the drawdowns within Hills Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects. There would be potential for moderate effects to vegetation around the reservoirs as a result of the drawdowns combined with cumulative effects, particularly climate change. This effect would entail an increasing trend toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

#### *4.6.2.4.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Coast Fork Willamette subbasin entails a species composition dominated by drought-tolerant plants including the more resilient invasive plants that thrive in disturbed areas.

The implementation of Alternative 2B would not have a more than negligible effect on the general trend of vegetative communities along the Coast Fork Willamette River becoming more dominated by drought-tolerant and invasive plants.

#### *4.6.2.4.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 2B would not have a more than negligible effect on the general trend of vegetative communities along the Mainstem Willamette River becoming more dominated by drought-tolerant and invasive plants.

### *4.6.2.5 Alternative 3A – Operations-Focused Fish Passage Alternative*

Overall, cumulative effects to vegetation would be moderate over the period of analysis. Changes to the vegetative community in terms of species composition would be affected by climate change, water withdrawals, federal and state wildlife and lands management, and invasive species management. Alternative 3A would also have moderate effects to the vegetative communities of the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in some subbasins as discussed below.

#### *4.6.2.5.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Santiam subbasin entails a species composition dominated by drought-tolerant plants and a growing population of the more resilient invasive plants that thrive in disturbed areas, which would have a moderate effect to vegetation within the subbasin.

With the implementation of Alternative 3A, gravel augmentation downstream of Big Cliff and Foster Dams will slightly improve conditions for vegetative communities along downstream reaches within the Santiam subbasin. On the other hand, the drawdowns within Green Peter and Detroit will further exacerbate the cumulative effects. At Detroit (fall and spring) and Green Peter (fall) drawdowns would be implemented and therefore, there would be potential for major effects to vegetation when combined with cumulative effects, particularly as a result of climate change. This effect would entail an increasing trend toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

#### *4.6.2.5.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Long Tom subbasin would entail a species composition with increasing numbers of drought-tolerant and invasive plants and this would constitute a moderate effect within the Long Tom subbasin. Alternative 3A would not change operations at Fern Ridge and therefore would not affect changes within the subbasin.

#### *4.6.2.5.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of vegetative communities in the McKenzie subbasin would entail a species composition with increasing populations of drought-tolerant and invasive plants along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 3A, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for vegetative communities along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make vegetation around the reservoirs more susceptible to climate change effects. At Cougar, a deep spring drawdown would be implemented and at Cougar and Blue River, a deep fall drawdown would be implemented. These deep drawdowns would potentially cause moderate effects to vegetation around the reservoirs when combined with cumulative effects, particularly climate change. This would push trends toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

#### *4.6.2.5.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of vegetative communities in the Middle Fork Willamette subbasin would entail a species composition with increasing populations of drought-tolerant and invasive plants along downstream reaches due to climate change but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 3A, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for vegetative communities along downstream reaches within the Middle Fork Willamette subbasin. On the other hand, the drawdowns within Hills Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects. In addition to the drawdowns with minor vegetation effects, at Lookout Point, a deep spring drawdown would be implemented and at Lookout Point and Hills Creek, a deep fall drawdown would be implemented. These deep drawdowns would potentially cause major effects to vegetation around the reservoirs when combined with cumulative effects, particularly climate change. This effect would entail an increasing trend toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

#### *4.6.2.5.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Coast Fork Willamette subbasin entails a species composition dominated by drought-tolerant plants including the more resilient invasive plants that thrive in disturbed areas.

The implementation of Alternative 3A would not have a more than negligible effect on the general trend of vegetative communities along the Coast Fork Willamette River becoming more dominated by drought-tolerant and invasive plants.

#### *4.6.2.5.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 3A would not have a more than negligible effect on the general trend of vegetative communities along the Mainstem Willamette River becoming more dominated by drought-tolerant and invasive plants.

#### 4.6.2.6 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)

Overall, cumulative effects to vegetation would be moderate over the period of analysis. Changes to the vegetative community in terms of species composition would be affected by climate change, water withdrawals, federal and state wildlife and lands management, and invasive species management. Alternative 3B would also have moderate effects to the vegetative communities of the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in some subbasins as discussed below. Alternative 3B is very similar to 3A. The primary differences are related to locations of the drawdowns and the fact that deep drawdowns occurring at Cougar would be to the elevation of the diversion tunnel.

##### 4.6.2.6.1 Santiam Subbasin

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Santiam subbasin entails a species composition dominated by drought-tolerant plants and a growing population of the more resilient invasive plants that thrive in disturbed areas, which would have a moderate effect to vegetation within the subbasin.

With the implementation of Alternative 3B, gravel augmentation downstream of Big Cliff and Foster Dams will slightly improve conditions for vegetative communities along downstream reaches within the Santiam subbasin. On the other hand, the drawdowns within Green Peter and Detroit will further exacerbate the cumulative effects. At both Detroit (fall) and Green Peter (fall and spring) deep drawdowns would be implemented and therefore, there would be potential for major effects to vegetation when combined with cumulative effects, particularly as a result of climate change. This effect would entail an increasing trend toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

##### 4.6.2.6.2 Long Tom Subbasin

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Long Tom subbasin would entail a species composition with increasing numbers of drought-tolerant and invasive plants and this would constitute a moderate effect within the Long Tom subbasin. Alternative 3B would not change operations at Fern Ridge and therefore would not affect changes within the subbasin.

#### *4.6.2.6.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of vegetative communities in the McKenzie subbasin would entail a species composition with increasing populations of drought-tolerant and invasive plants along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 3B, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for vegetative communities along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make vegetation around the reservoirs more susceptible to climate change effects. At Cougar, a deep spring drawdown would be implemented and at Cougar and Blue River, a deep fall drawdown would be implemented. These deep drawdowns would potentially cause moderate effects to vegetation around the reservoirs when combined with cumulative effects, particularly climate change. This would push trends toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

#### *4.6.2.6.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of vegetative communities in the Middle Fork Willamette subbasin would entail a species composition with increasing populations of drought-tolerant and invasive plants along downstream reaches due to climate change but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 3B, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for vegetative communities along downstream reaches within the Middle Fork Willamette subbasin. On the other hand, the drawdowns within Hills Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects. In addition to the drawdowns with minor vegetation effects, at Hills Creek, a deep spring drawdown would be implemented and at Lookout Point and Hills Creek, a deep fall drawdown would be implemented. These deep drawdowns would potentially cause moderate effects to vegetation around the reservoirs when combined with cumulative effects, particularly climate change. This effect would entail an increasing trend toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

#### *4.6.2.6.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Coast Fork Willamette subbasin entails a species composition dominated by drought-tolerant plants including the more resilient invasive plants that thrive in disturbed areas.

With the implementation of Alternative 3B, the drawdowns at Cottage Grove and Dorena would make vegetation around the reservoirs more susceptible to climate change effects. These drawdowns would potentially cause moderate effects to vegetation around the reservoirs when combined with cumulative effects, particularly climate change. This would push trends toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

#### *4.6.2.6.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 3B would not have a more than negligible effect on the general trend of vegetative communities along the Mainstem Willamette River becoming more dominated by drought-tolerant and invasive plants.

### ***4.6.2.7 Alternative 4 – Structures-Based Fish Passage Alternative***

Overall, cumulative effects to vegetation would be anticipated to be moderate over the period of analysis. However, Alternative 4 would not contribute substantially to the changes in the vegetative communities of the WVS. Changes to the vegetative community in terms of species composition would be affected to a greater magnitude by climate change, water withdrawals, federal and state wildlife and lands management, and invasive species management than by Alternative 4. Cumulative effect summaries for Alternative 4 by subbasin are provided below.

#### *4.6.2.7.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Santiam subbasin entails a species composition dominated by drought-tolerant plants and a growing population of the more resilient invasive plants that thrive in disturbed areas, which would have a moderate effect to vegetation within the subbasin.

With the implementation of Alternative 4, gravel augmentation downstream of Big Cliff and Foster Dams will slightly improve conditions for vegetative communities along downstream reaches within the Santiam subbasin. On the other hand, the drawdowns within Green Peter and Detroit will would make vegetation around the reservoirs more susceptible to climate change effects, which would ultimately constitute a moderate effect, pushing trends toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

##### *4.6.2.7.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Long Tom subbasin would entail a species composition with increasing numbers of drought-tolerant and invasive plants and this would constitute a moderate effect within the Long Tom subbasin.

##### *4.6.2.7.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of vegetative communities in the McKenzie subbasin would entail a species composition with increasing populations of drought-tolerant and invasive plants along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 4, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for vegetative communities along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make vegetation around the reservoirs more susceptible to climate change effects, which would constitute a minor effect, pushing trends toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

##### *4.6.2.7.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of vegetative communities in the Middle Fork Willamette subbasin would entail a species composition with increasing populations of drought-tolerant and invasive plants along downstream reaches due to climate change but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 4, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for vegetative communities along downstream reaches within the Middle Fork Willamette subbasin. On the other hand, the drawdowns within Hills Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects. There would be potential for minor effects to vegetation around the reservoirs as a result of the drawdowns combined with cumulative effects, particularly climate change. This effect would entail an increasing trend toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

##### *4.6.2.7.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Coast Fork Willamette subbasin entails a species composition dominated by drought-tolerant plants including the more resilient invasive plants that thrive in disturbed areas.

With the implementation of Alternative 4, the drawdowns at Cottage Grove and Dorena would make vegetation around the reservoirs more susceptible to climate change effects. These drawdowns would potentially cause moderate effects to vegetation around the reservoirs when combined with cumulative effects, particularly climate change. This would push trends toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

##### *4.6.2.7.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 4 would not have a more than negligible effect on the general trend of vegetative communities along the Mainstem Willamette River becoming more dominated by drought-tolerant and invasive plants.

#### *4.6.2.8 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Overall, cumulative effects to vegetation would be moderate over the period of analysis. Changes to the vegetative community in terms of species composition would be affected by climate change, water withdrawals, federal and state wildlife and lands management, and invasive species management. Alternative 5 (as with Alternative 2B) would also have moderate effects to the vegetative communities of the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in some subbasins as discussed below. Most notably at Cougar reservoir, because deep fall and spring drawdowns would be included as a part of Alternative 5 (as with Alternative 2B) there would be potential for major effects to vegetation around the reservoir when combined with climate change effects. The effects of Alternative 5 when combined with cumulative effects are identical to those of Alternative 2B as presented in Section 4.6.2.4. Cumulative effect summaries for Alternative 5 by subbasin are provided below.

#### *4.6.2.8.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Santiam subbasin entails a species composition dominated by drought-tolerant plants and a growing population of the more resilient invasive plants that thrive in disturbed areas, which would have a moderate effect to vegetation within the subbasin.

With the implementation of Alternative 5, gravel augmentation downstream of Big Cliff and Foster Dams will slightly improve conditions for vegetative communities along downstream reaches within the Santiam subbasin. On the other hand, the drawdowns within Green Peter and Detroit will further exacerbate the cumulative effects. Particularly at Green Peter, where a deep fall drawdown would be implemented, there would be potential for major effects to vegetation when combined with cumulative effects, particularly climate change. This effect would entail an increasing trend toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

#### *4.6.2.8.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Long Tom subbasin would entail a species composition with increasing numbers of drought-tolerant and invasive plants and this would constitute a moderate effect within the Long Tom subbasin. Alternative 5 would not change operations at Fern Ridge and therefore would not affect changes within the subbasin.

#### *4.6.2.8.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of vegetative communities in the McKenzie subbasin would entail a species composition with increasing populations of drought-tolerant and invasive plants along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 5, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for vegetative communities along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make vegetation around the reservoirs more susceptible to climate change effects. Particularly at Cougar, where deep fall and spring drawdowns would be implemented, there would be potential for moderate effects to vegetation when combined with cumulative effects, particularly climate change. This would push trends toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

#### *4.6.2.8.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of vegetative communities in the Middle Fork Willamette subbasin would entail a species composition with increasing populations of drought-tolerant and invasive plants along downstream reaches due to climate change but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 5, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for vegetative communities along downstream reaches within the Middle Fork Willamette subbasin. On the other hand, the drawdowns within Hills Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects. There would be potential for moderate effects to vegetation around the reservoirs as a result of the drawdowns combined with cumulative effects, particularly climate change. This effect would entail an increasing trend toward a species composition dominated by drought-tolerant and invasive plants around the reservoirs.

#### *4.6.2.8.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and

Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would add additional stress on vegetation around the reservoirs. Therefore, the general trend of vegetative communities in the Coast Fork Willamette subbasin entails a species composition dominated by drought-tolerant plants including the more resilient invasive plants that thrive in disturbed areas.

The implementation of Alternative 5 would not have a more than negligible effect on the general trend of vegetative communities along the Coast Fork Willamette River becoming more dominated by drought-tolerant and invasive plants.

###### *4.6.2.8.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 5 would not have a more than negligible effect on the general trend of vegetative communities along the Mainstem Willamette River becoming more dominated by drought-tolerant and invasive plants.

## 4.7 WETLANDS

### 4.7.1 Cumulative Effects Analysis Methodology for Wetlands

#### *4.7.1.1 Cumulative Actions Applicable to Wetlands*

Past, present, and RFFAs that, when considered together with the Proposed Action and alternatives, would have cumulative effects on wetlands include:

- WVS Dams and Reservoirs: construction and past operations and maintenance (see section 4.2.1.1) as well as ongoing operations and maintenance (see section 4.2.2)
- WRB Population Growth and Development: increased development extent and intensity within the Willamette River Basin (see section 4.2.1.2)
- RFFA 1: Future population growth and accompanying urban, industrial, and commercial development
- RFFA 2: Future agricultural development
- RFFA 3: Water withdrawals for municipal, industrial, and agricultural uses
- RFFA 4: Decarbonizing the energy sector with renewable energy sources
- RFFA 5: Federal and state wildlife and lands management
- RFFA 7: Tribal, state, and local fish and wildlife improvement
- RFFA 8: Invasive species management
- RFFA 9: Climate change

Some of the other RFFAs discussed in Section 4.2.3 would not change wetlands in the Willamette Basin or any changes would be negligible. These include:

- RFFA 6: Fishery management and killer whales. Because flows would not have more than a negligible effect as a result of this RFFA, wetlands would not be affected.
- RFFA 10: Mining operations. Mining operations have a negligible effect on wetlands.
- RFFA 11: Timber and logging industry operations. Timber and logging operations have a negligible effect on wetlands.

Therefore, these RFFAs are dismissed from further analysis.

### 4.7.2 Cumulative Effects to Wetlands by Alternative

The WVS dams and reservoirs are currently authorized for flood control, hydropower, pollution abatement, fish and wildlife conservation, recreation, irrigation, municipal and industrial water supply, and water quality. Wetlands within the WRB have been changed from the natural condition by the construction and operation of the WVS dams and reservoirs, dams constructed by other entities (Section 4.1.2.1.1), urban and rural development and land use, transportation infrastructure development, dredging and sediment management, and proliferation of invasive plant species as a result of much of this development. The cumulative effect is the conversion of complex stream reaches with a variety of habitats that support a variety of vegetative communities to inland lakes (reservoirs) and simplification of the regulated river reaches that provide less overbank flows and hydrology available to sustain streamside wetlands. In addition, certain invasive plants have proliferated in these hydrologic conditions which changes the character of wetlands within the WVS, limiting ecological functions.

Future population growth and accompanying urban, industrial, and commercial development (RFFA 1) occurring in the WRB would continue to affect wetlands by further impacting (excavating/filling) wetlands during construction activities. Development related to decarbonizing the energy sector with renewable energy sources (RFFA 4) such as wind and solar projects would affect wetlands similarly. There are construction standards and regulations in regard to protecting wetlands during development; however, wetlands would be impacted as permitted by regulatory agencies. Therefore, the cumulative actions associated with this development would create adverse, additive, and moderate effects to wetlands.

Future agricultural development (RFFA 2) occurring in historical floodplains would further impact wetlands and ecological function within these areas. Outside of the urban growth boundaries within the WRB, this floodplain development would likely be in the form of larger ranchettes or properties that take advantage of the hydrology in soils within low-lying areas. These areas may persist as wetlands but ecological function would be limited as they would be dominated by a monoculture of non-native crop species. Some of the plants associated with these agricultural areas are also invasive and would spread into downstream streamside wetlands. In addition, agricultural development with livestock also affects wetlands by modifying hydrology and soils during grazing and spreading non-native invasive plants. The cumulative actions associated with agricultural development would create adverse, additive, and minor effects to wetlands.

Water withdrawals for municipal, industrial, and agricultural uses (RFFA 3) would have the effect of either decreasing reservoir water surface elevation, decreasing instream flows, or a combination of both. Decreased water surface elevation would decrease the extent of soil saturation in proximity to reservoirs and WVS stream reaches, which would affect wetlands in these areas by changing wetland hydrology. By wetland hydrology being limited during a greater portion of the year and growing season, wetland areas may shrink or change in character affecting wetland function. These cumulative actions would create adverse, additive, and moderate effects to wetlands. These effects have largely been considered in Section 3.7 as they relate to the hydrologic effects for each alternative.

Federal and state wildlife and lands management (RFFA 5) happen throughout the regulated and unregulated portions of the watershed and are conservation focused or expected to occur with similar actions and rates as in the recent past. National forests, wilderness areas, and wildlife refuges (listed in Section 4.2.6) management actions, will continue as currently undertaken. The cumulative actions would be additive and cause moderate effects to wetlands.

Tribal, state, and local fish and wildlife improvement (RFFA 7) includes river and floodplain restoration actions and potentially environmental flows to inundate floodplain areas. Environmental flows have been performed historically in the Willamette system but have been limited in magnitude to non-damaging peak flows similar to smaller regulated flood events. The floodplain restoration actions usually involve existing or historical riverine wetlands within the floodplain and are thought to benefit wetlands by spreading flows out across the floodplain and reestablishing wetland hydrology. These cumulative actions would create beneficial, additive, and minor effects to wetlands within the WVS.

Invasive species management (RFFA 8) includes a range of vegetation management actions (e.g., herbicide application, mowing, controlled burns, etc.) taken by federal, state, and local agencies as well as private organizations to combat the spread of invasive plant species (see section 3.6.1.3.1 for more information). Vegetation management within the WRB would likely continue at the same rate as it currently is undertaken. Limiting the proliferation of invasive plant species benefits wetlands by helping to maintain a more diverse native plant community that improves the ecological function of wetlands. Invasive plant species management would create beneficial, additive, and moderate effects to wetlands within the WVS.

Climate change (RFFA 9) would affect wetlands primarily due to longer drier summers. Wetland hydroperiods (how long wetlands are inundated or wetland soils are saturated) would change for some wetlands which would change the wetland plant community and potentially cause wetland area to shrink. See the climate change sections of each alternative in section 3.6 for more information. Ultimately, climate change effects would be adverse, additive, and have moderate effects to wetlands within the WVS.

In general, the RFFAs have an adverse, additive, moderate effect on wetlands throughout the WRB. Continued development throughout the basin and all the actions associated with increased population within both urban and rural areas as well as other RFFA's that cause additional stress on wetlands (e.g., water withdrawals, invasive plant proliferation, and climate change) would decrease wetland acreage and impair or eliminate ecological functions of wetlands. On the other hand, wetlands and associated ecological functions would continue to be enhanced or maintained by restoration actions within the floodplains and management of invasive plant species. General trends described in this section apply to all subbasins within the WVS. Differences in the cumulative effects per subbasin will be described in the discussion below.

#### *4.7.2.1 No Action Alternative*

In addition to the cumulative effects listed above (particularly climate change), there would likely be additional effects to wetlands under the No Action Alternative. As discussed in section 3.7.2.2, the effects of the No Action Alternative would have both a beneficial and an adverse effect to vegetative communities in the WVS. The beneficial effect of the NAA is that water storage in the reservoirs would be maintained and would continue to support wetland hydrology around the reservoirs that may not otherwise exist. The adverse effect is that riverine wetlands along reaches downstream of the USACE projects would continue to rely primarily on precipitation since stream flows would continue to be managed for flood control, limiting hydrology available to wetlands across the floodplain. The NAA on its own would have negligible to minor adverse effects to wetlands, as it would maintain existing conditions. Combined with cumulative effects (primarily climate change), there would be adverse moderate effects to wetlands within the WVS in the form of changes to wetland acreage and ecological functions associated with wetlands.

#### *4.7.2.2 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Overall, cumulative effects to wetlands would be anticipated to be moderate over the period of analysis. However, Alternative 1 would not contribute substantially to the changes to wetlands of the WVS. Changes to wetland acreage and ecological functions associated with wetlands would be affected to a greater magnitude by climate change, water withdrawals, and invasive species management than by Alternative 1. Cumulative effect summaries for Alternative 1 by subbasin are provided below.

##### *4.7.2.2.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Santiam subbasin entails decreases to wetland acreage and ecological functions associated with wetlands as a result of cumulative effects which have an adverse moderate effect to wetlands within the subbasin.

With the implementation of Alternative 1, gravel augmentation downstream of Big Cliff and Foster Dams will slightly improve hydrologic conditions for wetlands along downstream reaches within the Santiam subbasin. On the other hand, the drawdowns within Green Peter and Detroit will further exacerbate the cumulative effects thereby increasing trends toward decreases to wetland acreage and ecological functions associated with wetlands. Combined with cumulative effects, an adverse moderate effect to wetlands would be anticipated.

##### *4.7.2.2.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Long Tom subbasin would entail decreases to wetland acreage and ecological functions associated with wetlands and this would constitute a moderate effect within the Long Tom subbasin. Alternative 1 would not change operations at Fern Ridge and therefore would not affect changes to wetlands within the subbasin.

#### *4.7.2.2.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wetlands in the McKenzie subbasin would entail decreases to wetland acreage and ecological functions associated with wetlands along downstream reaches due to climate change (an adverse moderate effect) but would remain largely unchanged around Cougar and Blue River reservoirs.

With the implementation of Alternative 1, gravel augmentation downstream of Cougar and Blue River dams will slightly improve hydrologic conditions for wetlands along downstream reaches within the McKenzie subbasin. On the other hand, the drawdowns at Cougar reservoir would make wetlands around the reservoirs more susceptible to climate change effects but ultimately, only minor adverse effects to wetlands would be anticipated around Cougar reservoir because of increased storage.

#### *4.7.2.2.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Falls Creek, Hills Creek, and Lookout Point, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Middle Fork Willamette subbasin entails decreases to wetland acreage and ecological functions associated with wetlands along downstream reaches and around the reservoirs. These cumulative effects would constitute a moderate effect to wetlands within the subbasin primarily because of climate change.

With the implementation of Alternative 1, gravel augmentation downstream of the WVS dams will slightly improve conditions for vegetative communities along downstream reaches within the Middle Fork Willamette subbasin. On the other hand, the drawdowns at Falls Creek, Hills Creek, and Lookout Point reservoirs will further exacerbate the cumulative effects thereby increasing trends toward decreases to wetland acreage and ecological functions associated with wetlands around the reservoirs, which would be considered a moderate effect.

#### *4.7.2.2.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of vegetative communities in the Coast Fork Willamette subbasin entails decreases to wetland acreage and ecological functions associated with wetlands along downstream reaches and around the reservoirs.

With the implementation of Alternative 1, increased storage at Cottage Grove and Dorena would offset lower reservoir elevations anticipated as a result of cumulative effects during conservation season; however, the drawdowns within Cottage Grove and Dorena will further exacerbate the cumulative effects thereby increasing trends toward decreases to wetland acreage and ecological functions associated with wetlands, an adverse moderate effect.

##### *4.7.2.2.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 1 would not have a more than negligible effect on the general trend of decreases to wetland acreage and ecological functions associated with wetlands along downstream reaches.

#### ***4.7.2.3 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (includes structural downstream passage at Cougar Dam)***

Overall, cumulative effects to wetlands would be moderate over the period of analysis. Changes to wetlands in terms of wetland acreage and ecological functions would be affected by climate change, water withdrawals, and invasive species management primarily. Alternative 2A would also have moderate effects to the wetlands within the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in some subbasins as discussed below.

##### *4.7.2.3.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would put additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Santiam subbasin entails decreases to wetland acreage and ecological functions associated with wetlands, which would have a moderate effect to wetlands within the subbasin.

With the implementation of Alternative 2A, gravel augmentation downstream of Big Cliff and Foster Dams will slightly improve conditions for wetlands along downstream reaches within the Santiam subbasin. On the other hand, the drawdowns within Green Peter and Detroit will further exacerbate cumulative effects. Particularly at Green Peter, where a deep fall drawdown would be implemented, there would be potential for major effects to wetlands when combined with cumulative effects, particularly climate change. This effect would entail an increasing trend toward decreases to wetland acreage and ecological functions associated with wetlands around Green Peter.

##### *4.7.2.3.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would add additional stress on wetlands around the reservoir. Therefore, the general trend of vegetative communities in the Long Tom subbasin would entail decreases to wetland acreage and ecological functions associated with wetlands and this would constitute a moderate effect within the Long Tom subbasin. Alternative 2A would not change operations at Fern Ridge and therefore would not affect changes within the subbasin.

##### *4.7.2.3.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wetlands in the McKenzie subbasin would entail decreases to wetland acreage and ecological functions associated with wetlands along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 2A, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for wetlands along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make wetlands around the reservoirs more susceptible to climate change effects, which would constitute a minor effect, pushing trends toward decreases to wetland acreage and ecological functions associated with wetlands around the reservoirs.

##### *4.7.2.3.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wetlands in the Middle Fork Willamette subbasin would entail decreases to wetland acreage and ecological functions associated with wetlands along downstream reaches due to climate change but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 2A, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for wetlands along downstream reaches within the Middle Fork Willamette subbasin. On the other hand, the drawdowns within Hills Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects. There would be potential for moderate effects to wetlands around the reservoirs as a result of the drawdowns combined with cumulative effects, particularly climate change. This effect would entail an increasing trend toward decreases to wetland acreage and ecological functions associated with wetlands around the reservoirs.

##### *4.7.2.3.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Coast Fork Willamette subbasin entails decreases to wetland acreage and ecological functions associated with wetlands.

The implementation of Alternative 2A would not have a more than negligible effect on the general trend of decreases to wetland acreage and ecological functions associated with wetlands within the Coast Fork Willamette.

##### *4.7.2.3.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 2A would not have a more than negligible effect on the general trend of decreases to wetland acreage and ecological functions associated with wetlands along downstream reaches.

#### *4.7.2.4 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Overall, cumulative effects to wetlands would be moderate over the period of analysis. Changes to wetlands in terms of changes to wetland acreage and ecological functions would be affected by climate change, water withdrawals, and invasive species management. Alternative 2B would also have moderate effects to the wetlands of the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in some subbasins as discussed below. Most notably at Cougar reservoir, because deep fall and spring drawdowns would be included as a part of Alternative 2B (as opposed to Alternative 2A) there would be potential for major effects to wetlands around the reservoir when combined with climate change effects.

#### *4.7.2.4.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Santiam subbasin entails decreases to wetland acreage and ecological functions, which would have a moderate effect to wetlands within the subbasin.

With the implementation of Alternative 2B, gravel augmentation downstream of Big Cliff and Foster Dams would slightly improve conditions for vegetative communities along downstream reaches within the Santiam subbasin. On the other hand, the drawdowns within Green Peter and Detroit would further exacerbate the cumulative effects. Particularly at Green Peter, where a deep fall drawdown would be implemented, there would be potential for major effects to wetlands when combined with cumulative effects, particularly climate change. This effect would entail decreases to wetland acreage and ecological functions of wetlands around the reservoirs.

#### *4.7.2.4.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Long Tom subbasin would entail decreases to wetland acreage and ecological functions and this would constitute a moderate effect within the Long Tom subbasin. Alternative 2B would not change operations at Fern Ridge and therefore would not affect changes within the subbasin.

#### *4.7.2.4.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wetlands in the McKenzie subbasin would entail decreases to wetland acreage and ecological functions along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 2B, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for wetlands along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make wetlands around the reservoirs more susceptible to climate change effects. Particularly at

Cougar, where deep fall and spring drawdowns would be implemented, there would be potential for moderate adverse effects to wetlands when combined with cumulative effects, particularly climate change. This would push trends toward decreases to wetland acreage and ecological functions around the reservoirs.

#### *4.7.2.4.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wetlands in the Middle Fork Willamette subbasin would entail decreases to wetland acreage and ecological functions along downstream reaches due to climate change but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 2B, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for vegetative communities along downstream reaches within the Middle Fork Willamette subbasin. On the other hand, the drawdowns within Hills Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects. There would be potential for moderate effects to wetlands around the reservoirs as a result of the drawdowns combined with cumulative effects, particularly climate change. This effect would entail an increasing trend toward decreases to wetland acreage and ecological functions around the reservoirs.

#### *4.7.2.4.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Coast Fork Willamette subbasin entails decreases to wetland acreage and ecological functions.

The implementation of Alternative 2B would not have a more than negligible effect on the general trend of decreases to wetland acreage and ecological functions associated with wetlands within the Coast Fork Willamette.

#### *4.7.2.4.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 2B would not have a more than negligible effect on the general trend of decreases to wetland acreage and ecological functions associated with wetlands along downstream reaches.

#### *4.7.2.5 Alternative 3A – Operations-Focused Fish Passage Alternative*

Overall, cumulative effects to wetlands would be moderate over the period of analysis. Changes to wetlands in terms of changes to wetland acreage and ecological functions would be affected by climate change, water withdrawals, and invasive species management. Alternative 3A would also have moderate effects to the wetlands of the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in some subbasins as discussed below.

##### *4.7.2.5.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Santiam subbasin entails decreases to wetland acreage and ecological functions, which would have a moderate effect to wetlands within the subbasin.

With the implementation of Alternative 3A, gravel augmentation downstream of Big Cliff and Foster Dams will slightly improve conditions for wetlands along downstream reaches within the Santiam subbasin. On the other hand, the drawdowns within Green Peter and Detroit will further exacerbate the cumulative effects. At Detroit (fall and spring) and Green Peter (fall) drawdowns would be implemented and therefore, there would be potential for major adverse effects to wetlands when combined with cumulative effects, particularly as a result of climate change. This effect would entail an increasing trend toward decreases to wetland acreage and ecological functions around the reservoirs.

##### *4.7.2.5.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Long Tom subbasin would entail decreases to wetland acreage and ecological functions and this would constitute a moderate effect within the Long Tom subbasin. Alternative 3A would not change operations at Fern Ridge and therefore would not affect changes within the subbasin.

#### *4.7.2.5.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wetlands in the McKenzie subbasin would entail decreases to wetland acreage and ecological functions along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 3A, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for wetlands along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make wetlands around the reservoirs more susceptible to climate change effects. At Cougar, a deep spring drawdown would be implemented and at Cougar and Blue River, a deep fall drawdown would be implemented. These deep drawdowns would potentially cause moderate effects to wetlands around the reservoirs when combined with cumulative effects, particularly climate change. This would push trends toward decreases of wetland acreage and ecological functions around the reservoirs.

#### *4.7.2.5.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wetlands in the Middle Fork Willamette subbasin would entail decreases to wetland acreage and ecological functions along downstream reaches due to climate change but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 3A, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for wetlands along downstream reaches within the Middle Fork Willamette subbasin. On the other hand, the drawdowns within Hills Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects. In addition to the drawdowns with minor effects to wetlands, at Lookout Point, a deep spring drawdown would be implemented and at Lookout Point and Hills Creek, a deep fall drawdown would be implemented. These deep drawdowns would potentially cause major effects to wetlands around the reservoirs when combined with cumulative effects, particularly climate change. This effect would entail decreases to wetland acreage and ecological functions around the reservoirs.

##### *4.7.2.5.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Coast Fork Willamette subbasin entails decreases to wetland acreage and ecological functions.

The implementation of Alternative 3A would not have a more than negligible effect on the general trend of decreases to wetland acreage and ecological functions associated with wetlands within the Coast Fork Willamette.

##### *4.7.2.5.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 3A would not have a more than negligible effect on the general trend of decreases to wetland acreage and ecological functions associated with wetlands along downstream reaches.

#### ***4.7.2.6 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)***

Overall, cumulative effects to wetlands would be moderate over the period of analysis. Changes to wetlands in terms of changes to wetland acreage and ecological functions would be affected by climate change, water withdrawals, and invasive species management. Alternative 3B would also have moderate effects to the wetlands of the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in some subbasins as discussed below. Alternative 3B is very similar to 3A. The primary differences are related to locations of the drawdowns and the fact that deep drawdowns occurring at Cougar would be to the elevation of the diversion tunnel.

##### *4.7.2.6.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Santiam subbasin entails decreases to wetland acreage and ecological functions, which would have a moderate effect to wetlands within the subbasin.

With the implementation of Alternative 3B, gravel augmentation downstream of Big Cliff and Foster Dams will slightly improve conditions for wetlands along downstream reaches within the Santiam subbasin. On the other hand, the drawdowns within Green Peter and Detroit will further exacerbate the cumulative effects. At both Detroit (fall) and Green Peter (fall and spring) deep drawdowns would be implemented and therefore, there would be potential for major effects to wetlands when combined with cumulative effects, particularly as a result of climate change. This effect would entail an increasing trend toward decreases of wetland acreage and ecological functions around the reservoirs.

#### *4.7.2.6.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetland in the Long Tom subbasin would entail decreases to wetland acreage and ecological functions and this would constitute a moderate effect within the Long Tom subbasin. Alternative 3B would not change operations at Fern Ridge and therefore would not affect changes within the subbasin.

#### *4.7.2.6.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wetlands in the McKenzie subbasin would entail decreases to wetland acreage and ecological functions along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 3B, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for wetlands along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make wetlands around the reservoirs more susceptible to climate change effects. At Cougar, a deep spring drawdown would be implemented and at Cougar and Blue River, a deep fall drawdown would be implemented. These deep drawdowns would potentially cause moderate effects to wetlands around the reservoirs when combined with cumulative effects, particularly climate change. This would push trends toward decreases of wetland acreage and ecological functions around the reservoirs.

#### *4.7.2.6.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wetlands in the Middle Fork Willamette subbasin would entail decreases to wetland acreage and ecological functions along downstream reaches due to climate change but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 3B, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for wetlands along downstream reaches within the Middle Fork Willamette subbasin. On the other hand, the drawdowns within Hills Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects. In addition to the drawdowns with minor wetland effects, at Hills Creek, a deep spring drawdown would be implemented and at Lookout Point and Hills Creek, a deep fall drawdown would be implemented. These deep drawdowns would potentially cause moderate effects to wetlands around the reservoirs when combined with cumulative effects, particularly climate change. This effect would entail decreases to wetland acreage and ecological functions around the reservoirs.

#### *4.7.2.6.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Coast Fork Willamette subbasin entails decreases to wetland acreage and ecological functions.

With the implementation of Alternative 3B, the drawdowns at Cottage Grove and Dorena would make wetlands around the reservoirs more susceptible to climate change effects. These drawdowns would potentially cause moderate effects to wetlands around the reservoirs when combined with cumulative effects, particularly climate change. This would push trends toward decreases of wetland acreage and ecological functions around the reservoirs.

#### *4.7.2.6.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 3B would not have a more than negligible effect on the general trend of decreases to wetland acreage and ecological functions associated with wetlands along downstream reaches.

### *4.7.2.7 Alternative 4 – Structures-Based Fish Passage Alternative*

Overall, cumulative effects to wetlands would be anticipated to be moderate over the period of analysis. However, Alternative 4 would not contribute substantially to the changes in the wetlands of the WVS. Changes to wetlands in terms of changes to wetland acreage and ecological functions would be affected to a greater magnitude by climate change, water withdrawals, and invasive species management than by Alternative 4. Cumulative effect summaries for Alternative 4 by subbasin are provided below.

#### *4.7.2.7.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Santiam subbasin entails decreases of wetland acreage and ecological functions, which would have a moderate effect to wetlands within the subbasin.

With the implementation of Alternative 4, gravel augmentation downstream of Big Cliff and Foster Dams will slightly improve conditions for wetlands along downstream reaches within the Santiam subbasin. On the other hand, the drawdowns within Green Peter and Detroit will would make wetlands around the reservoirs more susceptible to climate change effects, which would ultimately constitute a moderate effect, pushing trends toward decreases of wetland acreage and ecological functions around the reservoirs.

#### *4.7.2.7.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Long Tom subbasin would entail decreases of wetland acreage and ecological functions and this would constitute a moderate effect within the Long Tom subbasin. Alternative 4 would not change operations at Fern Ridge and therefore would not affect changes within the subbasin.

#### *4.7.2.7.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wetlands in the McKenzie subbasin would entail decreases of wetland acreage and ecological functions along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 4, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for wetlands along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make wetlands around the reservoirs more susceptible to climate change effects, which would constitute a minor effect, pushing trends toward decreases of wetland acreage and ecological functions around the reservoirs.

##### *4.7.2.7.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wetlands in the Middle Fork Willamette subbasin would entail decreases of wetland acreage and ecological functions along downstream reaches due to climate change but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 4, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for wetlands along downstream reaches within the Middle Fork Willamette subbasin. On the other hand, the drawdowns within Hills Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects. There would be potential for minor effects to wetlands around the reservoirs as a result of the drawdowns combined with cumulative effects, particularly climate change. This effect would entail an increasing trend toward decreases of wetland acreage and ecological functions around the reservoirs.

##### *4.7.2.7.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Coast Fork Willamette subbasin entails decreases to wetland acreage and ecological functions.

With the implementation of Alternative 4, the drawdowns at Cottage Grove and Dorena would make wetland around the reservoirs more susceptible to climate change effects. These drawdowns would potentially cause moderate effects to wetlands around the reservoirs when combined with cumulative effects, particularly climate change. This would push trends toward decreases of wetland acreage and ecological functions around the reservoirs.

##### *4.7.2.7.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 4 would not have a more than negligible effect on the general trend of decreases to wetland acreage and ecological functions associated with wetlands along downstream reaches.

#### ***4.7.2.8 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)***

Overall, cumulative effects to wetlands would be moderate over the period of analysis. Changes to wetlands in terms of changes to wetland acreage and ecological functions would be affected by climate change, water withdrawals, and invasive species management. Alternative 5 (as with Alternative 2B) would also have moderate effects to the wetlands of the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in some subbasins as discussed below. Most notably at Cougar reservoir, because deep fall and spring drawdowns would be included as a part of Alternative 5 (as with Alternative 2B) there would be potential for major effects to wetlands around the reservoir when combined with climate change effects. The effects of Alternative 5 when combined with cumulative effects are identical to those of Alternative 2B as presented in Section 4.7.2.4. Cumulative effect summaries for Alternative 5 by subbasin are provided below.

##### *4.7.2.8.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Santiam subbasin entails decreases to wetland acreage and ecological functions, which would have a moderate effect to wetlands within the subbasin.

With the implementation of Alternative 5, gravel augmentation downstream of Big Cliff and Foster Dams would slightly improve conditions for vegetative communities along downstream reaches within the Santiam subbasin. On the other hand, the drawdowns within Green Peter and Detroit would further exacerbate the cumulative effects. Particularly at Green Peter, where a deep fall drawdown would be implemented, there would be potential for major effects to wetlands when combined with cumulative effects, particularly climate change. This effect would entail decreases to wetland acreage and ecological functions of wetlands around the reservoirs.

##### *4.7.2.8.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Long Tom subbasin would entail decreases to wetland acreage and ecological functions and this would constitute a moderate effect within the Long Tom subbasin. Alternative 5 would not change operations at Fern Ridge and therefore would not affect changes within the subbasin.

##### *4.7.2.8.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wetlands in the McKenzie subbasin would entail decreases to wetland acreage and ecological functions along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 5, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for wetlands along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make wetlands around the reservoirs more susceptible to climate change effects. Particularly at Cougar, where deep fall and spring drawdowns would be implemented, there would be potential for moderate adverse effects to wetlands when combined with cumulative effects, particularly climate change. This would push trends toward decreases to wetland acreage and ecological functions around the reservoirs.

##### *4.7.2.8.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wetlands in the Middle Fork Willamette subbasin would entail decreases to wetland acreage and ecological functions along downstream reaches due to climate change but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 5, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for vegetative communities along downstream reaches within the Middle Fork Willamette subbasin. On the other hand, the drawdowns within Hills

Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects. There would be potential for moderate effects to wetlands around the reservoirs as a result of the drawdowns combined with cumulative effects, particularly climate change. This effect would entail an increasing trend toward decreases to wetland acreage and ecological functions around the reservoirs.

##### *4.7.2.8.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would add additional stress on wetlands around the reservoirs. Therefore, the general trend of wetlands in the Coast Fork Willamette subbasin entails decreases to wetland acreage and ecological functions.

The implementation of Alternative 5 would not have a more than negligible effect on the general trend of decreases to wetland acreage and ecological functions associated with wetlands within the Coast Fork Willamette.

##### *4.7.2.8.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 5 would not have a more than negligible effect on the general trend of decreases to wetland acreage and ecological functions associated with wetlands along downstream reaches.

## 4.8 FISH AND AQUATIC HABITAT

### 4.8.1 Cumulative Effects Analysis Methodology for Fish and Aquatic Habitat

#### *4.8.1.1 Cumulative Actions Applicable to Fish and Aquatic Habitat*

Past actions include the initial authorization and implementation of the Willamette System. At this time, fish populations were in precipitous decline due to overfishing and industrialization. Several hatcheries were constructed by the state to support angling. Water quality was degraded by logging activity. Once the Willamette System was implemented, the floodplain became more channelized, water quality began to improve, urbanization increased, and migratory fish were excluded from a large proportion of spawning habitat in the upper Willamette tributaries. Downstream fish populations were affected by regulated flows. The present actions are characterized by continued decline of salmon and steelhead populations and a decrease in life history diversity due to limited juvenile outmigration opportunities for those spawned above dams. The hatchery program has had negative impacts on natural origin fish. The introduction of hatchery non-native summer steelhead has negatively impacted winter steelhead through genetic influence (introgression) and competition. The effects of the proposed actions for ESA-listed fish and aquatic species are described in Chapter 3. The following describes Reasonable Foreseeable Future Actions (RFFAs), when considered together with the Proposed Action and alternatives, would have cumulative effects on fish and aquatic habitat, that include:

- RFFA 1 - Future population growth and accompanying urban, industrial, and commercial development
- RFFA 2 - Future agricultural development
- RFFA 3 - Water withdrawals for municipal, industrial, and agricultural uses
- RFFA 4 - Decarbonizing the energy sector with renewable energy sources
- RFFA 6 - Federal and state wildlife and lands management
- RFFA 7 - Pacific Ocean fishery management
- RFFA 8 - Tribal, state, and local fish and wildlife improvement
- RFFA 9 - Invasive species management
- RFFA 10 - Climate change

Some of the other RFFAs discussed in Section 4.2.3 would not change effects on fish and aquatic habitat in the Willamette Basin or only negligibly alter the WVS dam and reservoir operations and as such would not have a cumulative effect on fish and aquatic habitat:

RFFA 5 – Effects from emissions from the transportation sector would not be expected to have a direct impact on fish and aquatic habitat. Effects from emissions would be expected to contribute to future climate change through contribution to GHG emissions, and therefore these effects will be considered under RFFA 10.

RFFA 11 - Most future mining activities would be expected in either Clackamas or Douglas counties. Very little of the WRB occurs in Douglas County, therefore any effects from mining on WRB fish would be largely expected within the Clackamas County in the Clackamas River Sub-basin. These effects could include water quality degradation from sedimentation or release of hazardous materials into natural water bodies or those connected with natural water bodies within the Clackamas River Sub-basin.

RFFA 12 - Little timber harvest is expected to occur in the WRB since about 71% of Western Oregon forests are in Federal ownership, all of which is not available for harvest, and harvest rates are predicted to remain stable or gradually decline. Forest lands in ownership by the State of Oregon or in private ownership generally occur in the foothills of the Cascade Mountains and Coast Range portions of the WRB. Where harvest occurs on these smaller portions of the WRB, harvest can increase water run-off rates, increase sedimentation, and increase water temperatures. These effects reduce the quality and availability of aquatic habitat for native fish and aquatic organisms using forested streams until forests re-establish over the decades following harvest.

### 4.8.2 Cumulative Effects to Fish and Aquatic Habitat by Measure

RFFA 1 –

*Within the counties that comprise the WRB, human populations are continuing to increase. This growth is occurring primarily in urban metropolitan areas with smaller increases in rural areas.*

*If the relationship between the increase in population and the increase in developed land continues into the future, and mirrors the trend that existed from 1982 to 2017, developed land area of the WRB from 2020 to 2050 would be estimated to increase by 28 percent.*

*Municipal water demands may increase, which may be met by increased withdrawals from the WVS.*

*Increased urban development would decrease upland habitat and increase impervious surface in the area, changing the physical, chemical, hydrological, and ecological characteristics of stream ecosystems. In most cases, such changes are detrimental to native fish and wildlife.*

*The rate of exurban (area just beyond denser suburbs) development also appears to be increasing. Exurban development is generally associated with direct habitat conversion and loss for fish and wildlife species. Human population growth and development often leads to increased discharges of non-point source pollutants in stormwater runoff from residential, commercial, industrial, agricultural, recreational, and transportation land uses.*

*Projects to deepen channels or modify ports in Portland, OR may necessitate increasing numbers of ships and cargo tonnage on the lower Willamette and increasing rail freight and truck traffic* *on transportation corridors in the WRB that are linked to that port. Increased volumes of materials such as hazardous products and fuels that power trains, vessels, and trucks will likely move through the WRB in response to the demands of a growing population.*

*With increased movement of raw materials and manufactured goods via all three modes, more accidents and spills would be likely. Mining, logging, trade, and transportation projects also influence the hydrology, water quality, and land use in the WRB and WVS. Overall, this RFFA interacts cumulatively with all of the resources listed in Table 4.2-6.*

Future population growth and accompanying urban, industrial, and commercial development (RFFA 1) would increase local inflow in winter into river reaches downstream of the WVS dams during and increase demand for water withdrawals in consumptive uses (see RFFA 3 analysis below). The increased runoff could increase non-point source pollutants affecting fish health, behavior and survival. Increased winter flows could increase inundation of off-channel river features and the flood plain, which may provide additional habitat for rearing native fish. Increased demand for water withdrawals associated with population growth and development would increase summer water temperatures where they decrease instream flow. Fish habitat availability could increase or decrease depending on the timing and magnitude of instream flow changes, river reach affected, and the fish species life history and life stage.

RFFA 2 –

*Human population growth and related development have contributed to the decline of agricultural lands within the WRB.*

*Given the population projections shown in Table 4.2-4 that show strong growth for each of the 10 counties, land conversion and development pressures are likely to continue and the area of cropland within the WRB will likely continue to diminish. Reduced cropland acreage may reduce demands for agricultural irrigation water withdrawn from the WRB. Less cropland could also result in less soil erosion from wind and rain. Overall, this RFFA interacts cumulatively with most of the resources listed in Table 4.2-6, including but not limited to land use, soils, wetlands, listed species and critical habitat, socioeconomics, water supply, and visual resources.*

Agricultural land conversion and development pressures from population growth are projected to continue, and thus the area of cropland within the WRB will likely continue to diminish. Reduced cropland acreage may reduce demands for agricultural irrigation water withdrawn from the WRB. Decreased water demand would reduce water withdrawals for croplands from streams, and reduce exposure to agricultural pollutants from converted croplands. Negative effects from croplands on water quality and instream flow would be reduced, potentially improving habitat and survival of fish.

RFFA 3 – Future agricultural development

*Water usage within the WRB is likely to increase in the future, especially as human population growth, associated development, and climate change continue to affect water availability and scarcity in the region.*

*Water demand for irrigation usage (as seen in green) is predicted to remain relatively stable over the course of the 21$^{st}$ century; whereas water demand for municipal and residential usage (as seen in blue) would increase, likely linked to factors such as increasing human population projections and the evolving effects of climate change (WW2100, No Date).*

*By reducing the amount of water flowing through the WVS, increased withdrawals have implications for instream flow and for maintenance of riparian and aquatic habitats for fish and wildlife. New water withdrawals are typically subject to regulatory restrictions which might partially offset their negative effects. In the model's scenario, urban areas in general would be able to meet water needs with existing water rights, which would also include maintaining important water sources from outside the basin, such as the Bull Run watershed that supplies the City of Portland (WW2100, No Date). Overall, this RFFA interacts cumulatively with most of the resources listed in Table 4.2-6, including but not limited to water supply, socioeconomics, listed species and critical habitat, water quality, and hydrological processes.*

Increased water demands are expected to increase water withdrawals, particularly in the mainstem Willamette River downstream of Salem, OR (see WBR EA/BA). Increases in water withdrawals downstream from WVS dams in the 30 year period after the ROD (until ~2050) were accounted for when assessing the effects of the alternatives in the Environmental Consequences section, but not for streams in the WRB not regulated by the WVS, or beyond 2030. The effect of increased water withdrawals in these other streams, and in the WBR at large beyond 2030, would be to increase water temperatures in the WRB streams and rivers, potentially increase the concentration of toxic pollutants, and change habitat availability. The effect of increased water withdrawals on fish depends on the location, magnitude, timing and duration of the withdrawals and associated return flows. Because most of the increase in withdrawals are expected to occur during summer months downstream of Salem OR, the effect on ESA-listed fish (spring Chinook, winter steelhead and bull trout) will be limited since very few adults or juveniles are present in the mainstem during summer months. Increasing stored water releases from WVS reservoirs to meet new water withdrawals on the mainstem will increase flows in Willamette River tributaries, where both adult and juveniles are present in the summer. In these tributaries, increased flows would reduce peak summer water temperatures, however habitat availability could either increase or decrease depending on river reach, and species/lifestage.

RFFA 4 –

*Oregon's Renewable Portfolio Standard sets the requirement for how much of the state's electricity must come from renewable sources. In March 2016, this standard was set to require 50 percent of Oregon's electricity to come from renewables by 2040 (ODEQ, No Date-e).*

*Hydropower facilities typically provide more than half of the electricity generated in Oregon; natural gas fuels the second-largest share of Oregon's electricity generation, while non-hydroelectric renewable resources, including wind, biomass, solar, and geothermal power, provide almost the rest of Oregon's generation.*

*Decarbonizing the energy sector with renewable energy sources (RFFA 4) could have a number of conflicting impacts. Increasing development of wind and solar generation could reduce the demand for hydropower generation. Alternatively, the increase in solar and wind projects may increase the demand for hydropower due to its baseload and flexibility capabilities.*

If decarbonizing the energy sector with renewable energy sources reduces the demand for hydropower generation, this could benefit fish and aquatic habitat downstream by increasing operational flexibility of WVS dams and reservoirs to meet non-hydropower missions, including fish passage and water temperature operations. Conversely if decarbonizing the energy sector with renewable energy sources increases the demand for hydropower leading to increased power peaking operations or use of turbines at WVS dams, then these changes could decrease fish passage rates or survival and could affect water temperature management.

RFFA 6 – Federal and state wildlife and lands management

*The WRB contains abundant public lands, especially in the headwaters and higher elevations. These lands would continue to be managed for multiple purposes, such as watershed protection, wildlife and habitat conservation, recreation, livestock grazing, resource extraction (e.g., logging, mining), and other public uses.*

*The Oregon Department of Fish and Wildlife (ODFW) and the U.S. Fish and Wildlife Service (USFWS) would continue to implement management activities at the Willamette Valley National Wildlife Refuge Complex.*

*The way that these lands are managed within the WRB can have cumulative effects when added to the actions proposed in this Draft EIS. In particular, water management, soil management, vegetation management, and fire management can have important additive effects that could be either beneficial or adverse depending on the nature of the management action. Overall, this RFFA interacts cumulatively with most of the resources listed in Table 4.2-6, including but not limited to land use, water and air quality, socioeconomics, flood risk management, water supply, recreation, listed species and critical habitat, hazardous algal blooms, tribal and cultural resources, and environmental justice.*

Baker et al. (2004) discuss alternative futures for land use in the WRB in 2050. Likely actions included those that converted agricultural to urban land use and higher prioritization on wildlife and conservation initiatives. The suite of actions analyzed under this PEIS are intended to be compatible with multiple land use approaches and conservation obligations. With the exception of future water availability, it is expected that conservation initiatives would improve the population status of endangered fish in the WRB.

It is expected that with the implementation of passage and conservation initiatives, the state's hatchery program could result in competing objectives for recreational angling and conservation. The original intent of the authorization for game fish hatcheries did not consider the recreational benefits to the State from reservoir inundation, nor the increasing budget needed to maintain services for an expanding recreational fishing industry. Retail sales for sport fishing in 2016 generated $680M in revenue and provided 11,000 jobs in the State of Oregon (Testimony of the Northwest Sportfishing Industry Association 2015 to Congress). Despite this, the State has encountered budget shortfalls as mission areas expand for conservation and ESA requirements but available spending for these programs remains the same or has declined. In 2014, ODFW expressed concerns of shrinking budgets, expanding conservation responsibilities, and increasing reliance on fishing and hunting licenses to support program missions (ODFW 2014). The popularity and revenue generation from recreational angling is particularly dependent on active stocking of game fish, Chinook salmon, and summer steelhead hatchery production. Although the Corps has continued to contribute to game fish stocking and hatchery programs to meet harvest missions, the magnitude of angling activity in Oregon has expanded beyond the stream angling experience of the late 1930's. It is expected that the hatchery program will need to be adjusted to accommodate improved habitat and passage conditions.

It is also expected that the USFWS Willamette Valley Wildlife Refuge Complex, which includes Ankeny, William L. Finley, and Baskett Slough would continue to be managed into the future.

RFFA 7- Pacific Ocean fishery management

Commercial and recreational fishing of Pacific salmon is multi-jurisdictional and multi-national. The evaluation of oceanic fishing is overseen by many agencies. However, the most robust analyses come from the Pacific Salmon Commission. The Pacific Salmon Commission relies on observers, fishermen, and information from PIT, clipped, and coded wire tagged fish to inform harvest modeling. Much of this information can be used to forecast appropriate harvest management in the future. Alternative hatchery management and production schedules could impact hatchery produced fish available to harvest. However, it is expected that improved conservation initiatives could enhance overall abundance available to ocean fisheries. Wild fish are assumed to be natural more productive than their hatchery counterparts which would naturally favor a larger wild population if hatchery fish made up a smaller component and adequate downstream passage was implemented. Alternatively, changing ocean conditions and ocean survival can outstrip the benefits of passage and reduced hatchery pressure in a given year (see Appendix E). Therefore, it is expected that fishing performance in the future would be at least as variable as it is at present.

RFFA 8- Tribal, state, and local fish and wildlife improvement

Tribal, state, and local governments work independently or collaboratively on initiatives geared toward conservation, restoration, and public access to wildlife resources. Tribal actions are related to restoration and access to wildlife resources. Initiatives to preserve cultural resources is ongoing and expected to continue.

The state has several programs focused on conservation and habitat restoration. The 2010 memorandum of understanding details a wildlife mitigation program run jointly with Bonneville Power Administration and funded by Bonneville Power Administration. The program is intended to mitigate for the effects of inundation and construction of the Willamette Valley Project by acquiring land for purposes of habitat restoration. This program is expected to continue under the terms and deadlines of that memorandum and that the effects will result in an improvement to endangered fish and aquatic wildlife. The state also operates several wildlife conservation, research, internship and public outreach programs with local and private conservation entities. These programs will directly positively impact fish and wildlife through habitat restoration and mitigation actions and indirectly positively impact fish in wildlife through public education on wildlife resource management.

RFFA 9- Invasive species management

The state of Oregon with funding from BPA manages invasive species removal. Several local agencies also surveil for invasive species and evaluate invasive species risk. Many of these local efforts are also integrated with habitat restoration. It is expected that with changes to water availability, future urbanization and withdrawals, the risk for invasive species to colonize in the Willamette in the future will be greater. Invasive species management may need to be increased to avoid detrimental effects in the future. Invasive species may have direct impacts through competition or predation, or indirect effects through reduction of critical habitat attributes.

RFFA 10- Climate change

*The RMJOC-II report (2018) found the following for the 2020 to 2049 time period:*

- Temperatures in the region have already warmed about 1.5 degrees Fahrenheit (°F) since the 1970s. Temperatures are expected to warm another 1 to 4°F by the 2030s.
- Future precipitation trends are more uncertain, but higher precipitation is likely for the rest of the 21st century, particularly in the winter months. Already-dry summers could become drier.
- The incidence of large forest fires as seen in Figure 4.2-6 has increased since the early 1980s and is projected to continue increasing through the 21st century as air surface temperatures continue to rise. Wildfire alters the land surface and can have strong influences on runoff, vegetation dynamics, erosion and sediment transport, and ecosystem processes. Strong seasonality and dependence on spring snowmelt positions the WRB to be at risk for increased fires due to the effects of climate change.
- Average winter snowpacks in the mountains surrounding the Willamette Valley are very likely to decline over time as more winter precipitation falls as rain instead of snow.
- By the 2030s, higher average fall and winter flows on WRB streams and rivers, earlier peak spring runoff, and longer periods of low summer flows are very likely.

*Overall, this RFFA interacts cumulatively with all of the resources listed in Table 4.2-6.*

Effects of climate change were accounted for when assessing the effects of the alternatives in the Environmental Consequences section to 2050. As discussed in this section, we made the following assumptions about the effects from climate change resulting in higher precipitation in winter and higher air temperatures on fish in the WRB:

**Table 4.8-1. Climate Change Assumptions**

| | Increasing winter flow, decreasing summer flow and reservoir levels | Increasing water temperatures in streams and reservoirs |
|---|---|---|
| Adult holding and spawning | Decrease in available habitat | Increase in pre-spawn mortality |
| Incubation | Mortality from redd dewatering or scouring | Earlier emergence and earlier ocean entry |
| Rearing and Emigration | Increased frequency of displacement or mortality during flooding. Decrease or elimination of summer habitat; particularly for bull trout at decreasing elevations | Decrease or elimination of summer habitat; particularly for bull trout at decreasing elevations. Earlier emigration timing and earlier ocean entry of salmon and steelhead. |

Below dams, effects of climate change on fish will vary depending on WVS dams and reservoir operations. During the conservation storage and delivery seasons (Feb 1 to Sep 31) stored water can supplement natural flows in later spring to fall downstream of WVS dams. Discharged water temperatures from each dam can influence downstream river reaches to near each tributary confluence with the mainstem Willamette River. WVS stored water releases in later spring to fall can also influence water temperatures in the mainstem Willamette River. These effects will help reduce some of the negative effects of higher temperatures (increase in adult pre-spawn mortality from higher temperatures, increase in egg or juvenile displacement from higher winter flows, decrease in rearing habitat from higher water temperatures). The extent dams and reservoirs influence below dam flows and water temperatures depends on the measures included in each WVS PEIS alternative.

Most future mining activities would be expected in either Clackamas or Douglas counties. Very little of the WRB exists in Douglas County, therefore any effects from mining on WRB fish would be largely expected within the Clackamas County in the Clackamas River Sub-basin. These effects could include water quality degradation from sedimentation or release of hazardous materials into natural water bodies or those connected with natural water bodies within the Clackamas River Sub-basin. Poor water quality could decrease fish health and survival.

**Table 4.8-2. Summation of Effects of RFFAs on Fish and Aquatic Habitat**

| RFFA # | RFFA Title | Summary effects on fish and aquatic habitat |
|---|---|---|
| RFFA 1 | Future population growth and accompanying urban, industrial, and commercial development | Increased runoff leading to non-point source pollutants affecting fish health, behavior and survival; increased winter flows leading to increased off-channel or floodplain habitat for rearing fish; increased summer water temperatures where withdrawals decrease instream flow leading to changes in fish habitat availability, particularly in the mainstem Willamette River. |
| RFFA 2 | Future agricultural development | Conversion/development of croplands will decrease water demand and water pollutants from croplands, improving aquatic habitat for fish. |
| RFFA 3 | Water withdrawals for municipal, industrial, and agricultural uses | Increased water demands, particularly below Salem, leading to increased water temperatures, pollutant concentrations, and change aquatic habitat availability. Limited negative effect on ESA-listed fish expected (spring Chinook, winter steelhead and bull trout) since very few adults or juveniles are present in the mainstem during summer months, and some positive effects may occur within tributaries from increasing stored water releases from WVS reservoirs on tributaries to meet new water withdrawals on the mainstem. |
| RFFA 4 | Decarbonizing the energy sector with renewable energy sources | If the demand for hydropower generation decreases, this could benefit fish and aquatic habitat downstream by increasing operational flexibility of WVS dams and reservoirs to meet non-hydropower missions, included those for fish passage and water temperature. Conversely if the demand for hydropower increases leading to increased power peaking operations or use of turbines at WVS dams, then these changes could decrease fish passage rates or survival and could affect water temperature management. |
| RFFA 6 | Federal and state wildlife and lands management | Adjustments to fish hatchery programs to accommodate for improved fish passage conditions at dams and reduce effects on conservation of wild fish; continued operation and maintenance of the USFWS Willamette Valley Wildlife Refuge Complex |
| RFFA 7 | Pacific Ocean fishery management | Fishing performance in the future would be at least as variable as it is at present due to variability in ocean conditions and fish survival in the ocean, and changes in salmon hatchery production. |
| RFFA 8 | Tribal, state, and local fish and wildlife improvement | Positively impact on fish through habitat restoration and mitigation actions and indirectly positive impacts on fish through public education on resource management. Locations and magnitude of impacts uncertain. |
| RFFA 9 | Invasive species management | Increased negative effects (primarily competition and predation) on native fish and aquatic habitat availability from invasive species. |
| RFFA 10 | Climate change | Decrease in habitat available for spawning and rearing. Increase in adult pre-spawn mortality, change in incubation and emergence timing and decrease in summer habitat availability and quality |

#### *4.8.2.1 No Action Alternative*

Negative impacts from the RFFAs include those from increased winter runoff, increased water temperatures from water withdrawals, and non-point source pollutants from population growth and development degrading aquatic habitat conditions and reducing fish health and survival. Water withdrawals for municipal and industrial (M&I) uses will also decease flows downstream of Salem, however since very few are present in the mainstem during summer months, limited negative effects on ESA-listed fish (spring Chinook, winter steelhead and bull trout) are expected from these M&I withdrawals. Effects of decarbonizing the energy sector with renewable energy sources is difficult to predict, however if the demand for hydropower increases leading to increased power peaking operations or use of turbines at WVS dams, then these changes could decrease fish passage rates or survival and could affect water temperature management. Increased negative effects from invasive species on native fish (primarily competition and predation) is also expected to increase, in particular due to climate change effects favoring invasive species.

Some positive effects of RFFAs on fish and aquatic habitat in the WRB can also be expected. Conversion/development of croplands will decrease water demand and water pollutants, improving aquatic habitat conditions for fish. If the demand for hydropower generation decreases, this could benefit fish and aquatic habitat downstream by increasing operational flexibility of WVS dams and reservoirs to meet non-hydropower missions, included those for fish passage and water temperature. Fishing performance in the future would be at least as variable as it is at present due to variability in ocean conditions and fish survival in the ocean, and changes in salmon hatchery production. Ongoing and future aquatic and riparian habitat restoration and mitigation actions would also be expected to directly and indirectly have positive impacts on fish.

RFFAs are expected to infer a net negative impact in addition to the effects accounted for in the Environmental Consequences section. Poor fish passage conditions at WVS dams will continue to significantly constrain population viability of ESA-listed salmon and steelhead, and effects of RFFAs on habitat conditions below dams will further reduce population viability. Similarly, RFFAs also will infer a net negative impact for bull trout, stemming primarily from climate change-related contraction of existing habitat occupied above WVS dams (increased winter flows, decreased summer low flows, increased water temperatures) in high elevation areas. Under the NAA, bull trout do not have effective access to below dam habitat, however stream reaches below dams will further degraded in the future and not be expected to provide any suitable spawning areas, experience a reduction and degradation in available rearing habitat, and survival rates of bull trout below dams would be expected to decline due to increases in recognized risk factors (see fish analysis appendix X, section X).

#### *4.8.2.2 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Alternative 1 is a storage themed alternative with the intent to store water for multiple uses across the Corps' authorizations. Under Alternative 1, at-dam structures proposed for Detroit, Green Peter, Foster and Lookout Point dams provided for fish passage and water temperature management while promoting storage, integration with hydropower, and downstream water uses nearest communities that are expected to increase in population and likely water demand downstream. Minimum flows for fish as included are designed to adjust with real-time water availability, supporting downstream fish passage measures, and habitat and water temperature needs for fish below dams.

With respect to future population growth, urbanization, industrial, and commercial development, demand for this storage would increase and specific allocation would need to be forecasted with respect to fish and wildlife needs. While there may be greater public demand for access to stored water, fish and wildlife needs would also need to be prioritized. Given the uncertainty of water availability in the future and the expected increase in wildfire frequency with ongoing climate change, the ability to store more water earlier in the year may become a very valuable resiliency strategy. It is expected that as demand for agricultural use becomes less frequent with conversion to urban uses, negative impacts from effluent and agricultural runoff will positively affect fish and wildlife resources. Increased municipal water demand would likely compete with endangered fish and aquatic species needs such that stored water would likely need to be prioritized among interests. Increased urbanization expected in the future would likely mean a greater need for decarbonization and possibly greater demand for hydropower. This could indicate a need for stored water and a greater emphasis on at dam structural fish passage that is integrated with turbine operations. Federal and state land management downstream of project may be directly impacted by water storage practices, however, conservation efforts above project where the majority of quality habitat for endangered fish is expected to be, would likely be improved under Alternative 1. Pacific Ocean harvest management is unlikely to be directly affected but may be indirectly affected by the percentage of hatchery fish that make up total catch. It is expected that water storage would most likely support above dam populations of natural origin endangered fish, which are assumed to be more productive than their hatchery counterparts. While the catchability of hatchery origin fish may decrease, the catch of natural origin fish is expected to increase. Tribal, state, and local land management may be negatively impacted downstream of project depending on the allocation and water year type experienced in any given year. However, it is expected that the opportunity for improvement, on average, would be better than the No Action Alternative. Invasive species management may become more complex under Alternative 1. However, this complexity may well be buffered by the ability to allocate stored water such that negative impacts to endangered fish and aquatic species would be mitigated through adequate planning of stored water use. With respect to climate change, water storage is likely to be a more resilient planning strategy due to the fact that precipitation patterns and snow pack are expected to be more variable (and less predictable). While water availability forecasting is relatively limited, water storage early in the year allows for a buffer against unexpected climatic events that may occur later in the year (i.e., flows needed for fish later in the year). Overall, while Alternative 1 may not perform the best over other alternatives, it does provide some resiliency for fish and wildlife given the uncertainties with respect to urbanization, land use, climate change, and water use needs predicted in the future.

#### *4.8.2.3 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Alternative 2A is an integrated water management alternative that balances practical public need with operational flexibility that may better reflect the historic hydrograph with respect to endangered fish and aquatic species. This alternative integrates a mixture of at-dam downstream passage solutions with operational solutions. At-dam structural solutions to downstream fish passage are proposed at Detroit Dam, Foster Dam, and Lookout Point Dam. Operational downstream passage is proposed at Green Peter Dam and Cougar Dam. Future population growth under this alternative will likely have lesser impact to endangered fish and aquatic species due to implementation at projects where storage is prioritized over operational passage.

Under Alternative 2A, an at-dam structure proposed for Detroit and Lookout Point dams promote storage, integration with hydropower, and downstream water uses nearest communities that are expected to increase in population and likely water demand downstream. Operational measures for downstream fish passage are proposed for Green Peter and Cougar dams. Given the uncertainty of water availability in the future and the expected increase in wildfire frequency with ongoing climate change, the ability to store more water earlier in the year may become a very valuable resiliency strategy. Minimum flow targets proposed are responsive to water storage availability in the spring. Minimum flows for fish as included are designed to adjust with real-time water availability, supporting downstream fish passage measures, and habitat and water temperature needs for fish below dams. However, the reservoir drawdown to the regulating outlet at Cougar Dam in spring proposed at Cougar Dam for downstream fish passage will eliminate much of the ability to store water in Cougar Reservoir specifically.

It is expected that agricultural demand will decrease over time as use shifts to urban expansion and municipal uses. Water withdrawals are expected to increase which will impact endangered fish and aquatic species below project negatively. Demand for hydropower may increase which will likely show positive responses for endangered fish and aquatic species where at-dam/turbine friendly solutions are prioritized, a slightly positive effect on endangered fish and aquatic species where operational downstream passage is prioritized, and a detrimental effect from decarbonization leads to increased hydropower operations where operational downstream fish passage is prioritized. Federal and state wildlife and land management would likely be less affected in terms of direct and indirect effects. Where there are opportunities for storage at large projects such as Detroit where water availability would be more variable, agencies could incorporate adaptive planning. Where operational downstream fish passage is implemented, planning would be adaptive to endangered fish and aquatic species needs without sacrificing critical habitat. Pacific Ocean harvest would likely reflect outcomes described under Alternative 1. Tribal, state, and local wildlife management would likely reflect outcomes described under Alternative 1. Invasive species management would likely be complicated by the combination of at-dam storage and operational downstream passage approaches. This could result in management plans that are more reactive given that such operations have not yet been observed and monitored.

#### *4.8.2.4 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Alternative 2B is also an integrated water management alternative. Downstream fish passage at Cougar Dam is proposed as a spring and fall reservoir drawdown to the diversion tunnel in Alternative 2B, otherwise fish passage and water quality measures are the same in Alternative 2A and 2B. Operational fish passage at Cougar Dam proposed for this Alternative is estimated to be more effective that that proposed for Alternative 2A at Cougar Dam.

Future population growth under this alternative will likely have lesser impact to endangered fish and aquatic species due to implementation at projects where storage is prioritized over operational passage. Under Alternative 2B, an at-dam structure proposed for Detroit and Lookout Point dams promote storage, integration with hydropower, and downstream water uses nearest communities that are expected to increase in population and likely water demand downstream. Operational downstream passage is proposed at Green Peter and Cougar dams where urbanization downstream is unlikely to increase and effects on the public are expected to be less impactful.

Minimum flow targets proposed are responsive to water storage availability in the spring. Minimum flows for fish as included are designed to adjust with real-time water availability, supporting downstream fish passage measures, and habitat and water temperature needs for fish below dams. However, the reservoir drawdown to the regulating outlet at Cougar Dam in spring proposed at Cougar Dam for downstream fish passage will eliminate much of the ability to store water in Cougar Reservoir specifically.

It is expected that agricultural demand will decrease over time as use shifts to urban expansion and municipal uses. Water withdrawals are expected to increase which will impact endangered fish and aquatic species below project negatively. Demand for hydropower will likely increase which will likely show positive responses for endangered fish and aquatic species where at-dam/turbine friendly solutions are prioritized, a slightly positive effect on endangered fish and aquatic species where operational downstream passage is prioritized, and a detrimental effect on decarbonization where operational downstream passage is prioritized. Federal and state wildlife and land management would likely be less affected in terms of direct and indirect effects. Where there are opportunities for storage at large projects such as Detroit where water availability would be more variable, agencies could incorporate adaptive planning. Where operational downstream fish passage is implemented, planning would be adaptive to endangered fish and aquatic species needs without sacrificing critical habitat. Pacific Ocean harvest would likely reflect outcomes described under Alternative 1. Tribal, state, and local wildlife management would likely reflect outcomes described under Alternative 1. Invasive species management would likely be complicated by the combination of at-dam storage and operational downstream passage approaches. This could result in management plans that are more reactive given that such operations have not yet been observed and monitored.

#### *4.8.2.5 Alternative 3A – Operations-Focused Fish Passage Alternative*

Alternative 3A is focused on operational measures at WVS dams for fish passage and water quality. Operational measures for fish passage and water quality are less resilient to changes associated with RFFAs, when compared to structural measures, since structural measures are designed to be effective at a range of reservoir pool elevations and discharge rates, whereas operational measures effectiveness varies with reservoir elevation/volume, discharge outlets available, and discharge rates.

Minimum flows for fish as included are designed to adjust with real-time water availability in spring, supporting downstream fish passage measures, and habitat and water temperature needs for fish below dams. Given the uncertainty of water availability in the future and the expected increase in wildfire frequency with ongoing climate change, the ability to store more water earlier in the year may become a very valuable resiliency strategy.

Spring reservoir drawdowns for fish significantly decrease resiliency since the availability of storage water is substantially reduced. Spring drawdowns will reduce water available for supplementing naturally low flows in summer and fall, managing summer and fall water temperatures, and reduce reservoir habitat for fish remaining above dams. Spring drawdowns to regulating outlets occur at Detroit, Lookout Point, and Cougar dams in Alternative 3A.

Lower stream flows below dams resulting for spring drawdowns of reservoirs in the North Santiam, McKenzie and Middle Fork will be further negatively impacted by population growth and development, municipal and industrial (M&I) uses which increase water temperatures from water withdrawals, and non-point source pollutants reducing fish health and survival. However, since very few adults or juveniles are present in the mainstem during summer months, limited negative effects on ESA-listed fish (spring Chinook, winter steelhead and bull trout) are expected from M&I withdrawals in particular since most are predicted to occur downstream of Salem. If the demand for hydropower increases leading to increased power peaking operations or use of turbines at WVS dams, then these changes could decrease fish passage rates or survival and could affect water temperature management. Increased negative effects from invasive species on native fish (primarily competition and predation) is also expected to increase, in particular due to climate change effects favoring invasive species. Fishing performance in the future would be at least as variable as it is at present due to variability in ocean conditions and fish survival in the ocean, and changes in salmon hatchery production.

Some positive effects of RFFAs on fish and aquatic habitat in the WRB may counter-balance some of the negative effects. Conversion/development of croplands will decrease water demand and associated water pollutants. Adjustments to fish hatchery programs would be expected to accommodate for improved fish passage conditions at dams and reduce effects on wild fish conservation. If the demand for hydropower generation decreases, this could benefit fish and aquatic habitat downstream by increasing operational flexibility of WVS dams and reservoirs to meet non-hydropower missions, included those for fish passage and water temperature. Ongoing and future aquatic and riparian habitat restoration and mitigation actions would also be expected to directly and indirectly have positive impacts on fish.

#### *4.8.2.6 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)*

Alternative 3B is also focused on operational measures at WVS dams for fish passage and water quality. As described for 3A, operational measures for fish passage and water quality are less resilient to changes associated with RFFAs, when compared to structural measures. Spring drawdowns, in particular where they occur, significantly decrease resiliency. Spring drawdowns to regulating outlets occur at Green Peter and Hills Creek, and to the diversion tunnel at Cougar Dam in Alternative 3A.

Lower stream flows below dams resulting for spring drawdowns of reservoirs in the South Santiam, McKenzie and Middle Fork will be further negatively impacted by population growth and development, municipal and industrial (M&I) uses which increase water temperatures from water withdrawals, and non-point source pollutants reducing fish health and survival. However, since very few adults or juveniles are present in the mainstem during summer months, limited negative effects on ESA-listed fish (spring Chinook, winter steelhead and bull trout) are expected from M&I withdrawals in particular since most are predicted to occur downstream of Salem. Bull trout relying on Cougar Reservoir for rearing will likely re-distribute upstream into the South Fork McKenzie watershed or below Cougar Dam, which could lead to density dependent effects from habitat and food limitations and exposure to poorer habitat conditions lower in the McKenzie Sub-basin. If the demand for hydropower increases leading to increased power peaking operations or use of turbines at WVS dams, then these changes could decrease fish passage rates or survival and could affect water temperature management. Increased negative effects from invasive species on native fish (primarily competition and predation) is also expected to increase, in particular due to climate change effects favoring invasive species. Fishing performance in the future would be at least as variable as it is at present due to variability in ocean conditions and fish survival in the ocean, and changes in salmon hatchery production.

As for Alternative 3B, some positive effects of RFFAs on fish and aquatic habitat in the WRB may counter-balance some of the negative effects. Conversion/development of croplands will decrease water demand and associated water pollutants. Adjustments to fish hatchery programs would be expected to accommodate for improved fish passage conditions at dams and reduce effects on wild fish conservation. If the demand for hydropower generation decreases, this could benefit fish and aquatic habitat downstream by increasing operational flexibility of WVS dams and reservoirs to meet non-hydropower missions, included those for fish passage and water temperature. Ongoing and future aquatic and riparian habitat restoration and mitigation actions would also be expected to directly and indirectly have positive impacts on fish.

#### *4.8.2.7 Alternative 4 – Structures-Based Fish Passage Alternative*

Alternative 4 is a structural downstream passage themed alternative with the intent to prioritize and operate with a focus on ESA-listed fish species. Proposed downstream fish passage structures are proposed for Detroit, Foster, Cougar, Hills Creek and Lookout Point dams.

Minimum flows for fish as included are designed to adjust with real-time water availability in spring, supporting downstream fish passage measures, and habitat and water temperature needs for fish below dams. Given the uncertainty of water availability in the future and the expected increase in wildfire frequency with ongoing climate change, the ability to store more water earlier in the year may become a very valuable resiliency strategy.

With respect to future population growth, urbanization, industrial, and commercial development, demand for this storage would increase and specific allocation would need to be forecasted with respect to fish and wildlife needs. While there may be greater public demand for access to stored water, fish and wildlife needs would also need to be prioritized. Given the uncertainty of water availability in the future and the expected increase in wildfire frequency with ongoing climate change, the ability to store more water earlier in the year may become a more valuable resiliency strategy. It is expected that as demand for agricultural use becomes less frequent with conversion to urban uses, negative impacts from effluent and agricultural runoff will positively affect fish and wildlife resources. Increased municipal water demand would likely compete with endangered fish and aquatic species needs such that stored water would likely need to be prioritized among interests. Increased urbanization expected in the future would likely mean a greater need for decarbonization and possibly greater demand for hydropower. This could indicate a need for stored water and a greater emphasis on at dam structural fish passage that is integrated with turbine operations. Federal and state land management downstream of project may be directly impacted by water storage practices, however, conservation efforts above project where the majority of quality habitat for endangered fish is expected to be, would likely be improved under Alternative 1. Pacific Ocean harvest management is unlikely to be directly affected but may be indirectly affected by the percentage of hatchery fish that make up total catch. It is expected that water storage would most likely support above dam populations of natural origin endangered fish, which are assumed to be more productive than their hatchery counterparts. While the catchability of hatchery origin fish may decrease, the catch of natural origin fish is expected to increase. Tribal, state, and local land management may be negatively impacted downstream of project depending on the allocation and water year type experienced in any given year. However, it is expected that the opportunity for improvement, on average, would be better than the No Action Alternative. Invasive species management success is expected to be similar or better given the implementation of biological downstream flows. With respect to climate change, water storage is likely to be a more resilient planning strategy due to the fact that precipitation patterns and snowpack are expected to be more variable (and less predictable). While water availability forecasting is relatively limited, water storage early in the year allows a for a buffer against unexpected climatic events that may occur later in the year (i.e., flows needed for fish later in the year). Alternative 4 provides some resiliency for fish and wildlife given the uncertainties with respect to urbanization, land use, climate change, and water use needs predicted in the future.

#### *4.8.2.8 Alternative 5 – Integrated Water Management Flexibility and ESA-Listed Fish with Modified Flows Alternative*

Alternative 5 is functionally similar to Alternative 2B and it is anticipated that the cumulative effects under Alternative 5 will be indistinguishable from cumulative effects under Alternative 2B. Alternative 5, similar to alternatives 2A and 2B, is integrated water management alternative with small hydrological differences noted in Chapter 4 Hydrologic Processes. Downstream minimum flows are different below Big Cliff, Foster, Cougar and Dexter dams, otherwise fish passage and water quality measures are the same in alternatives 5 and 2B. Operational fish passage at Cougar Dam proposed for this Alternative is estimated to be more effective that that proposed for Alternative 2A at Cougar Dam.

Future population growth under this alternative will likely have lesser impact to endangered fish and aquatic species due to implementation at projects where storage is prioritized over operational passage. Under Alternative 5, at-dam structures for fish passage proposed for Detroit and Lookout Point dams promote storage, integration with hydropower, and downstream water uses nearest communities that are expected to increase in population and likely water demand downstream. Minimum flow targets proposed are responsive to water storage availability in the spring. Minimum flows for fish included are designed to adjust with real-time water availability Downstream fish passage operations at Green Peter Dam will utilize surface spill, promoting storage of water in the reservoir for fish other needs during the spring and summer. The reservoir drawdown to the regulating outlet at Cougar Dam in spring proposed at Cougar Dam for downstream fish passage will eliminate much of the ability to store water in Cougar Reservoir specifically. where urbanization downstream is unlikely to increase and effects on the public are expected to be less impactful.

It is expected that agricultural demand will decrease over time as use shifts to urban expansion and municipal uses. Water withdrawals are expected to increase which will impact endangered fish and aquatic species below project negatively. Demand for hydropower will likely increase which will likely show positive responses for endangered fish and aquatic species where at-dam/turbine friendly solutions are prioritized, a slightly positive effect on endangered fish and aquatic species where operational downstream passage is prioritized, and a detrimental effect on decarbonization where operational downstream passage is prioritized. Federal and state wildlife and land management would likely be less affected in terms of direct and indirect effects. Where there are opportunities for storage at large projects such as Detroit where water availability would be more variable, agencies could incorporate adaptive planning. Where operational downstream fish passage is implemented, planning would be adaptive to endangered fish and aquatic species needs without sacrificing critical habitat. Pacific Ocean harvest would likely reflect outcomes described under Alternative 1. Tribal, state, and local wildlife management would likely reflect outcomes described under Alternative 1. Invasive species management would likely be complicated by the combination of at-dam storage and operational downstream passage approaches. This could result in management plans that are more reactive given that such operations have not yet been observed and monitored.

## 4.9 WILDLIFE, BIRDS, AND TERRESTRIAL HABITAT

### 4.9.1 Cumulative Effects Analysis Methodology for Wildlife, Birds, and Terrestrial Habitat

#### *4.9.1.1 Cumulative Actions Applicable to Wildlife, Birds, and Terrestrial Habitat*

Past, present, and RFFAs that, when considered together with the Proposed Action and alternatives, would have cumulative effects on wildlife and associated habitat include:

- WVS Dams and Reservoirs: construction and past operations and maintenance (see section 4.2.1.1) as well as ongoing operations and maintenance (see section 4.2.2)
- WRB Population Growth and Development: increased development extent and intensity within the Willamette River Basin (see section 4.2.1.2)
- WVS Dams and Reservoirs: ongoing operations and maintenance (see section 4.2.2)
- RFFA 1: Future population growth and accompanying urban, industrial, and commercial development
- RFFA 2: Future agricultural development
- RFFA 3: Water withdrawals for municipal, industrial, and agricultural uses
- RFFA 4: Decarbonizing the energy sector with renewable energy sources
- RFFA 5: Federal and state wildlife and lands management
- RFFA 6: Fishery management and killer whales.
- RFFA 7: Tribal, state, and local fish and wildlife improvement
- RFFA 8: Invasive species management
- RFFA 9: Climate change
- RFFA 10: Mining operations
- RFFA 11: Timber and logging industry operations

### 4.9.2 Cumulative Effects to Wildlife, Birds, and Terrestrial Habitat by Alternative

The WVS dams and reservoirs are currently authorized for flood control, hydropower, pollution abatement, fish and wildlife conservation, recreation, irrigation, municipal and industrial water supply, and water quality. Wildlife species and wildlife habitat within the WRB has been affected by the construction and operation of the WVS dams and reservoirs, dams constructed by other entities (Section 4.1.2.1.1), urban and rural development and land use, transportation infrastructure development, dredging and sediment management and other land-altering activities. The cumulative effect is a decrease of biodiversity and changes to a variety of habitats that support a wide range of wildlife species. Simplification of the stream channels within the WVS limits habitat availability across the floodplains that support aquatic species while also extending upland habitat for terrestrial species that would not otherwise be available.

Future population growth and accompanying urban, industrial, and commercial development (RFFA 1) occurring in the WRB would continue to affect wildlife species by disturbing individuals and further fragmenting habitat during construction activities. Development related to decarbonizing the energy sector with renewable energy sources (RFFA 4) such as wind and solar projects would likely affect wildlife species and habitat similarly. There is particular guidance for federal actions involving development to protect certain ESA-listed species and critical habitat. However, some development-related impacts would be permitted and state and local actions would be less regulated. The cumulative actions associated with development would create adverse, additive, and moderate effects to wildlife and wildlife habitat.

Future agricultural development (RFFA 2) occurring in historical floodplains would further fragment wildlife habitat and passage within these areas. Outside of the urban growth boundaries within the WRB, this floodplain development would likely be in the form of larger ranchettes or properties that take advantage of the hydrology in soils within low-lying areas. These are areas that terrestrial wildlife species cross in order to access water. Fence installation, grazing livestock, and cultivating crops with machinery would affect wildlife by limiting passage through these areas. In addition, spreading invasive plant species from these areas can affect downstream riparian habitat that is important to many wildlife species. The cumulative actions associated with agricultural development would create adverse, additive, and moderate effects to wildlife and wildlife habitat.

Water withdrawals for municipal, industrial, and agricultural uses (RFFA 3) would have the effect of either decreasing reservoir water surface elevation, decreasing instream flows, or a combination of both. Decreased water surface elevation would affect aquatic species such as breeding amphibians and reptiles that depend on inundation at certain times of year for reproductive success. Many aquatic wildlife species also depend on wetland habitat that would be affected by decreasing water surface elevations. These cumulative actions would create adverse, additive, and moderate effects to wildlife species and wildlife habitat. These effects have largely been considered in Section 3.9 as they relate to the hydrologic effects of each alternative.

Federal and state wildlife and lands management (RFFA 5) happen throughout the regulated and unregulated portions of the watershed and are conservation focused or expected to occur with similar actions and rates as in the recent past. National forests, wilderness areas, and wildlife refuges (listed in Section 4.2.6) management actions, will continue as currently undertaken. Similarly, timber and logging industry operations (RFFA 11) will continue as currently undertaken throughout the watershed. The cumulations actions associated with these RFFA's would continue to affect wildlife and wildlife habitat by disturbing individuals, particularly during breeding periods, and fragmenting habitat. These cumulative actions would be additive and cause adverse moderate effects to wildlife and wildlife habitat.

Tribal, state, and local fish and wildlife improvement (RFFA 7) includes river and floodplain restoration actions and potentially environmental flows to inundate floodplain areas. Environmental flows have been performed historically in the Willamette system but have been limited in magnitude to non-damaging peak flows similar to smaller regulated flood events. These floodplain restoration actions would sometimes involve some consideration of wildlife effects and improvement of wildlife habitat. These cumulative actions would create beneficial, additive, and minor effects to wildlife and wildlife habitat within the WVS.

Invasive species management (RFFA 8) includes a range of management actions taken by federal, state, and local agencies as well as private organizations to combat the spread of invasive species, including invasive wildlife species. In addition, management of invasive plants can help by protecting wildlife habitat, like wetlands, where the ecological functions of the habitat would change with invasive plant infestation. Invasive species management within the WRB would likely continue at the same rate as it currently is undertaken. Invasive species management would create beneficial, additive, and moderate effects to wildlife and wildlife habitat within the WVS.

Climate change (RFFA 9) would affect wildlife and wildlife habitat primarily due to longer drier summers. Habitat that occurs in riparian areas, such as wetland and aquatic habitat, would shrink and the ecological functions would change and less able to support certain aquatic species. Water temperature would increase with climate change, which would affect fish and other forage species that wildlife species depend on. With increased water temperature there would be an increase in toxic algal blooms, which can adversely affect wildlife species and food chains. The seasonality of wildlife species (e.g., birds, reptiles, insects, etc.) life histories would need to adjust to the new climate patterns, which would have a number of adverse effects to species, interactions between species, and interactions with their habitats. See the climate change sections for each alternative in section 3.9 for more information. Ultimately, climate change effects would be adverse, additive, and have major effects to wetlands within the WVS.

In general, the RFFAs have an adverse, additive, major effect on wildlife and wildlife habitat throughout the WRB. Continued development throughout the basin and all the actions associated with increased population within both urban and rural areas as well as other RFFA's that cause additional stress on wildlife (e.g., water withdrawals, habitat fragmentation, and climate change) would decrease biodiversity and habitat available for wildlife species. On the other hand, conditions for wildlife and wildlife habitat would be enhanced or maintained by restoration actions within the floodplains and management of invasive species. General trends described in this section apply to all subbasins within the WVS. Differences in the cumulative effects per subbasin will be described in the discussion below.

#### *4.9.2.1 No Action Alternative*

Combined with the effects of the cumulative effects listed above (particularly climate change), there would likely be additional effects to wildlife and wildlife habitat under the No Action Alternative. As discussed in section 3.9.2.2, the effects of the No Action Alternative would have both a beneficial and an adverse effect to wildlife and wildlife habitat in the WVS. The beneficial effect of the NAA is that water storage in the reservoirs would be maintained and would continue to support hydrology in aquatic and wetland habitats at the reservoirs that may not otherwise exist. One adverse effect is that since stream flows would continue to be managed for flood control and confined to a fairly uniform channel, wildlife habitat along reaches downstream of the USACE projects would continue to be limited in diversity and amount available. In addition, without fish passage provided, forage species (including but not limited to salmonids) population size would be limited upstream of the WVS projects. The NAA on its own would have both minor beneficial and adverse effects to wildlife and wildlife habitat, maintaining existing conditions. Combined with cumulative effects (primarily climate change), there would be major adverse effects to wildlife within the WVS in the form of changes to suitable habitat acreage, water quality, and the seasonality of wildlife life histories.

#### *4.9.2.2 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Overall, cumulative effects to wildlife and wildlife habitat would be anticipated to be major over the period of analysis. However, Alternative 1 would not contribute substantially to the changes to wildlife and wildlife habitat within the WVS. Changes to biodiversity and suitable habitat availability would be affected to a greater magnitude by climate change, water withdrawals, and habitat fragmentation due to development than by Alternative 1. Cumulative effect summaries for Alternative 1 by subbasin are provided below.

##### *4.9.2.2.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers affecting stream flows and water quality. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would affect aquatic and wetland habitat around the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Santiam subbasin entails decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories. Cumulative effects would have an adverse major effect to wildlife and wildlife habitat within the subbasin.

With the implementation of Alternative 1, gravel augmentation downstream of Big Cliff and Foster Dams will slightly improve hydrologic conditions for aquatic and wetland habitat along downstream reaches within the Santiam subbasin. In addition, providing fish passage at Green Peter, Foster, and Detroit will slightly improve foraging opportunities for wildlife species within the subbasin. On the other hand, the drawdowns within Green Peter and Detroit will further exacerbate the cumulative effects thereby increasing trends of decreases to suitable habitat acreage. Combined with cumulative effects, an adverse major effect to wildlife and wildlife habitat would be anticipated.

#### *4.9.2.2.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would affect aquatic and wetland habitat at the reservoirs. Alternative 1 would improve foraging opportunities for wildlife slightly by providing downstream fish passage over the drop structures downstream of Fern Ridge. However, the overall trend of wildlife and wildlife habitat in the Long Tom subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories and this would constitute a major adverse effect within the Long Tom subbasin.

#### *4.9.2.2.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wildlife and wildlife in the McKenzie subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories largely due to climate change (an adverse major effect). It should be noted that aquatic and wetland habitat would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 1, gravel augmentation downstream of Cougar and Blue River dams will slightly improve hydrologic conditions for aquatic and wetland habitat along downstream reaches within the McKenzie subbasin. On the other hand, the drawdowns at Cougar reservoir would make aquatic and wetland habitat around the reservoirs more susceptible to climate change effects but ultimately, only minor adverse effects to wetlands would be anticipated around Cougar reservoir because of increased storage. Combined with the cumulative effects, a major adverse effect to wildlife and wildlife habitat is anticipated.

#### *4.9.2.2.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wildlife and wildlife habitat in the Middle Fork Willamette subbasin entails decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches due to climate change but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 1, gravel augmentation downstream of the WVS dams will slightly improve conditions for aquatic and wetland habitat along downstream reaches within the Middle Fork Willamette subbasin. Providing downstream fish passage at Lookout Point and Dexter would slightly improve foraging opportunities for wildlife species within the subbasin. On the other hand, the drawdowns at Falls Creek, Hills Creek, and Lookout Point reservoirs will further exacerbate the cumulative effects at the reservoirs thereby increasing trends toward decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories, which would be considered a major adverse effect overall for the subbasin.

##### *4.9.2.2.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would affect aquatic and wetland habitat around the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Coast Fork Willamette subbasin entails decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

With the implementation of Alternative 1, increased storage at Cottage Grove and Dorena would offset lower reservoir elevations anticipated as a result of cumulative effects during conservation season; however, the drawdowns within Cottage Grove and Dorena will further exacerbate the cumulative effects thereby increasing trends toward decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories. Ultimately, combined with cumulative effects, a major adverse effect would be anticipated.

##### *4.9.2.2.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 1 would not have a more than negligible effect on the general trend of decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches.

#### *4.9.2.3 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (includes structural downstream passage at Cougar Dam)*

Overall, cumulative effects to wildlife and wildlife habitat would be major over the period of analysis. Changes to wildlife and wildlife habitat in terms of biodiversity and suitable habitat availability would be affected by climate change, water withdrawals, and habitat fragmentation due to development. Alternative 2A would also have moderate effects to wildlife and wildlife habitat within the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in most subbasins as discussed below.

#### *4.9.2.3.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would affect aquatic and wetland habitat around the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Santiam subbasin entails decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories, which would have a major adverse effect to wildlife and wildlife habitat within the subbasin.

With the implementation of Alternative 2A, gravel augmentation downstream of Big Cliff and Foster Dams would slightly improve conditions for aquatic and wetland habitat along downstream reaches within the Santiam subbasin. Adding lamprey passage at Green Peter and downstream fish passage at Detroit and Foster would slightly improve foraging opportunities for wildlife species within the subbasin. Adding a WTC tower at Detroit would slightly improve water temperature for salmonids, which are important to piscivorous wildlife. On the other hand, the drawdowns within Green Peter and Detroit would further exacerbate cumulative effects. Particularly at Green Peter, where a deep fall drawdown would be implemented, there would be potential for major effects to aquatic and wetland habitat when combined with cumulative effects, particularly climate change. This major adverse effect would entail an increasing trend toward decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

#### *4.9.2.3.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would affect aquatic and wetland habitat around the reservoir. Therefore, the general trend of vegetative communities in the Long Tom subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories and this would constitute a major adverse effect within the Long Tom subbasin. Alternative 2A would not change operations at Fern Ridge and therefore would not affect changes within the subbasin.

#### *4.9.2.3.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wildlife and wildlife habitat in the McKenzie subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 2A, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for aquatic and wetland habitat along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. Adding downstream fish passage at Cougar would slightly improve foraging opportunities for wildlife species within the subbasin. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make aquatic and wetland habitat around the reservoirs more susceptible to climate change effects, which would constitute a minor adverse effect. Overall, coupled with cumulative effects, Alternative 2A would have a major adverse effect to wildlife and wildlife habitat along downstream reaches and a minor adverse effect around the reservoirs within the subbasin.

##### *4.9.2.3.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wildlife and wildlife habitat in the Middle Fork Willamette subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches due to climate change (a major adverse effect) but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 2A, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for aquatic and wetland habitat along downstream reaches within the Middle Fork Willamette subbasin. Providing downstream passage at Lookout Point would improve foraging opportunities and nutrient cycling for wildlife. On the other hand, the drawdowns within Hills Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects around reservoirs. Overall, within the subbasin there would be potential for major adverse effects to wildlife and wildlife habitat as a result of the drawdowns combined with cumulative effects, particularly climate change. This effect would entail an increasing trend toward decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

##### *4.9.2.3.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would affect aquatic and wetland habitat around the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Coast Fork Willamette subbasin entails decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

The implementation of Alternative 2A would not have a more than negligible effect on the general trend of decreases to decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories within the Coast Fork Willamette. Overall, a major adverse effect.

##### *4.9.2.3.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 2A would not have a more than negligible effect on the general trend of decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches.

#### *4.9.2.4 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Overall, cumulative effects to wildlife and wildlife habitat would be major over the period of analysis. Changes to wildlife and wildlife habitat in terms of biodiversity and suitable habitat availability would be affected by climate change, water withdrawals, and habitat fragmentation due to development. Alternative 2B would also have moderate effects to wildlife and wildlife habitat within the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in most subbasins as discussed below. Most notably at Cougar reservoir, because deep fall and spring drawdowns would be included as a part of Alternative 2B (as opposed to Alternative 2A) there would be potential for major effects to aquatic and wetland habitat around the reservoir when combined with climate change effects.

##### *4.9.2.4.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would affect aquatic and wetland habitat around the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Santiam subbasin entails decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories, which would have a major adverse effect to wildlife and wildlife habitat within the subbasin.

With the implementation of Alternative 2B, gravel augmentation downstream of Big Cliff and Foster Dams would slightly improve conditions for aquatic and wetland habitat along downstream reaches within the Santiam subbasin. Adding lamprey passage at Green Peter and downstream fish passage at Detroit and Foster would slightly improve foraging opportunities for wildlife species within the subbasin. Adding a WTC tower at Detroit would slightly improve water temperature for salmonids, which are important to piscivorous wildlife. On the other hand, the drawdowns within Green Peter and Detroit would further exacerbate cumulative effects. Particularly at Green Peter, where a deep fall drawdown would be implemented, there would be potential for major effects to aquatic and wetland habitat when combined with cumulative effects, particularly climate change. This major adverse effect would entail an increasing trend toward decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

##### *4.9.2.4.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would affect wildlife and wildlife habitat at the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Long Tom subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories and this would constitute a major adverse effect within the Long Tom subbasin. Alternative 2B would not change operations at Fern Ridge and therefore would not affect changes within the subbasin.

##### *4.9.2.4.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wildlife and wildlife habitat in the McKenzie subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 2B, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for aquatic and wetland habitat along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make aquatic and wetland habitat around the reservoirs more susceptible to climate change effects. Particularly at Cougar, where deep fall and spring drawdowns would be implemented, there would be potential for major adverse effects to wildlife and wildlife habitat when combined with cumulative effects, particularly climate change. This would push trends toward decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

#### *4.9.2.4.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wildlife and wildlife habitat in the Middle Fork Willamette subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches due to climate change (a major adverse effect) but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 2B, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for aquatic and wetland habitat along downstream reaches within the Middle Fork Willamette subbasin. Adding downstream fish passage at Lookout Point would slightly improve foraging opportunities for wildlife species within the subbasin. On the other hand, the drawdowns within Hills Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects at the reservoirs. There would be potential for major adverse effects to wildlife and wildlife habitat as a result of the drawdowns combined with cumulative effects, particularly climate change. This effect would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

#### *4.9.2.4.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would affect wildlife and wildlife habitat at the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Coast Fork Willamette subbasin entails decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

The implementation of Alternative 2B would not have a more than negligible effect on the general trend of decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories within the Coast Fork Willamette.

#### *4.9.2.4.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 2B would not have a more than negligible effect on the general trend of decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches.

#### *4.9.2.5 Alternative 3A – Operations-Focused Fish Passage Alternative*

Overall, cumulative effects to wildlife and wildlife habitat would be major over the period of analysis. Changes to wildlife and wildlife habitat in terms of biodiversity and suitable habitat availability would be affected by climate change, water withdrawals, and habitat fragmentation due to development. Alternative 3A would also have moderate effects to wildlife and wildlife habitat within the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in most subbasins as discussed below.

##### *4.9.2.5.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would affect aquatic and wetland habitat around the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Santiam subbasin entails decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories, which would have a major adverse effect to wildlife and wildlife habitat within the subbasin.

With the implementation of Alternative 3A, gravel augmentation downstream of Big Cliff and Foster Dams will slightly improve conditions for aquatic and wetland habitat along downstream reaches within the Santiam subbasin. Adding downstream fish passage at Big Cliff and Green Peter and lamprey passage at Green Peter would slightly improve foraging opportunities for wildlife species within the subbasin. On the other hand, the drawdowns within Green Peter and Detroit will further exacerbate the cumulative effects. At Detroit (fall and spring) and Green Peter (fall) drawdowns would be implemented and therefore, there would be potential for major adverse effects to wildlife and wildlife habitat when combined with cumulative effects, particularly as a result of climate change. This effect would entail an increasing trend toward decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

##### *4.9.2.5.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would affect wildlife and wildlife habitat at the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Long Tom subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories and this would constitute a major adverse effect within the Long Tom subbasin. Alternative 3A would not change operations at Fern Ridge and therefore would not affect changes within the subbasin.

#### *4.9.2.5.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wildlife and wildlife habitat in the McKenzie subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 3A, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for aquatic and wetland habitat along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. Adding lamprey passage at Blue River would slightly improve foraging opportunities for wildlife species within the subbasin. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make wildlife and wildlife habitat at the reservoirs more susceptible to climate change effects. At Cougar, a deep spring drawdown would be implemented and at Cougar and Blue River, a deep fall drawdown would be implemented. These deep drawdowns would potentially cause major adverse effects to wildlife and wildlife habitat around the reservoirs when combined with cumulative effects, particularly climate change. This would push trends toward decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

#### *4.9.2.5.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wildlife and wildlife habitat in the Middle Fork Willamette subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches due to climate change (a major adverse effect) but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 3A, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for aquatic and wetland habitat along downstream reaches within the Middle Fork Willamette subbasin. Adding lamprey passage at Hills Creek and downstream fish passage at Dexter, Fall Creek, and Hills Creek would slightly improve foraging opportunities for wildlife species within the subbasin. On the other hand, the drawdowns within Hills Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects. In addition to the drawdowns with minor effects, at Lookout Point, a deep spring drawdown would be implemented and at Lookout Point and Hills Creek, a deep fall drawdown would be implemented. These deep drawdowns would potentially cause major adverse effects to wildlife and wildlife habitat at the reservoirs when combined with cumulative effects, particularly climate change. This effect would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

#### *4.9.2.5.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would affect wildlife and wildlife habitat at the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Coast Fork Willamette subbasin entails decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

The implementation of Alternative 3A would not have a more than negligible effect on the general trend of decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories associated with wetlands within the Coast Fork Willamette.

#### *4.9.2.5.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 3A would not have a more than negligible effect on the general trend of decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches.

### ***4.9.2.6 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)***

Overall, cumulative effects to wildlife and wildlife habitat would be major over the period of analysis. Changes to wildlife and wildlife habitat in terms of biodiversity and suitable habitat availability would be affected by climate change, water withdrawals, and habitat fragmentation due to development. Alternative 3B would also have moderate effects to wildlife and wildlife habitat within the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in most subbasins as discussed below. Alternative 3B is very similar to 3A. The primary differences are related to locations of the drawdowns and the fact that deep drawdowns occurring at Cougar would be to the elevation of the diversion tunnel.

#### *4.9.2.6.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would affect aquatic and wetland habitat around the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Santiam subbasin entails decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories, which would have a major adverse effect to wildlife and wildlife habitat within the subbasin.

With the implementation of Alternative 3B, gravel augmentation downstream of Big Cliff and Foster Dams will slightly improve conditions for aquatic and wetland habitat along downstream reaches within the Santiam subbasin. Adding lamprey passage at Green Peter and downstream fish passage at Detroit would slightly improve foraging opportunities for wildlife species within the subbasin. On the other hand, the drawdowns within Green Peter and Detroit will further exacerbate the cumulative effects. At both Detroit (fall) and Green Peter (fall and spring) deep drawdowns would be implemented and therefore, there would be potential for major adverse effects to wildlife and wildlife habitat when combined with cumulative effects, particularly as a result of climate change. This effect would entail an increasing trend toward decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

##### *4.9.2.6.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would affect wildlife and wildlife habitat at the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Long Tom subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories and this would constitute a major adverse effect within the Long Tom subbasin. Alternative 3B would not change operations at Fern Ridge and therefore would not affect changes within the subbasin.

##### *4.9.2.6.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wildlife and wildlife habitat in the McKenzie subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 3B, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for aquatic and wetland habitat along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. Adding lamprey passage at Blue River would slightly improve foraging opportunities for wildlife species within the subbasin. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make wildlife and wildlife habitat around the reservoirs more susceptible to climate change effects. At Cougar, a deep spring drawdown would be implemented and at Cougar and Blue River, a deep fall drawdown would be implemented. These deep drawdowns would potentially cause major adverse effects to wildlife and wildlife habitat around the reservoirs when combined with cumulative effects, particularly climate change. This would push trends toward decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

#### *4.9.2.6.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wildlife and wildlife habitat in the Middle Fork Willamette subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches due to climate change (a major adverse effect) but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 3B, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for aquatic and wetland habitat along downstream reaches within the Middle Fork Willamette subbasin. Adding downstream fish passage at Dexter and Lookout Point and lamprey passage at Hills Creek would slightly improve foraging opportunities for wildlife species within the subbasin. On the other hand, the drawdowns within Hills Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects. In addition to the drawdowns with minor effects, at Hills Creek, a deep spring drawdown would be implemented and at Lookout Point and Hills Creek, a deep fall drawdown would be implemented. These deep drawdowns would potentially cause major adverse effects to wildlife and wildlife habitat at the reservoirs when combined with cumulative effects, particularly climate change. This effect would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

#### *4.9.2.6.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would affect wildlife and wildlife habitat around the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Coast Fork Willamette subbasin entails decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

With the implementation of Alternative 3B, the drawdowns at Cottage Grove and Dorena would make wildlife and wildlife habitat at the reservoirs more susceptible to climate change effects. These drawdowns would potentially cause major adverse effects to wetlands around the reservoirs when combined with cumulative effects, particularly climate change. This would push trends toward decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

#### *4.9.2.6.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 3B would not have a more than negligible effect on the general trend of decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches.

### ***4.9.2.7 Alternative 4 – Structures-Based Fish Passage Alternative***

Overall, cumulative effects to wildlife and wildlife habitat would be anticipated to be major adverse over the period of analysis. However, Alternative 4 would not contribute substantially to the changes in the wildlife and wildlife habitat of the WVS. Changes to wildlife and wildlife habitat in terms of changes to biodiversity and suitable habitat availability would be affected more by climate change, water withdrawals, and habitat fragmentation due to development than by Alternative 4. Cumulative effect summaries for Alternative 4 by subbasin are provided below.

#### *4.9.2.7.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would affect aquatic and wetland habitat around the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Santiam subbasin entails decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories, which would have a major adverse effect to wildlife and wildlife habitat within the subbasin.

With the implementation of Alternative 4, gravel augmentation downstream of Big Cliff and Foster Dams will slightly improve conditions for aquatic and wetland habitat along downstream reaches within the Santiam subbasin. Adding downstream fish passage at Detroit and Foster would slightly improve foraging opportunities for wildlife species within the subbasin. Adding a WTC tower at Detroit would slightly improve water temperature for salmonids, which are important to piscivorous wildlife. On the other hand, the drawdowns within Green Peter and Detroit will would make wildlife and wildlife habitat around the reservoirs more susceptible to climate change effects, which would ultimately constitute a major adverse effect, pushing trends toward decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

##### *4.9.2.7.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would affect wildlife and wildlife habitat at the reservoirs. Alternative 4 would improve foraging opportunities for wildlife slightly by providing downstream fish passage over the drop structures downstream of Fern Ridge. However, the overall trend of wildlife and wildlife habitat in the Long Tom subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories and this would constitute a major adverse effect within the Long Tom subbasin.

##### *4.9.2.7.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wildlife and wildlife habitat in the McKenzie subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 4, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for aquatic and wetland habitat along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. Adding downstream fish passage at Cougar would slightly improve foraging opportunities for wildlife species within the subbasin. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make wildlife and wildlife habitat at the reservoirs more susceptible to climate change effects, which would constitute a minor adverse effect. With the drawdowns, trends would continue to be pushed toward decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories within the subbasin. Major adverse effects would be anticipated along downstream reaches but only moderate adverse effects at the reservoirs when Alternative 4 effects and cumulative effects are combined.

##### *4.9.2.7.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wildlife and wildlife habitat in the Middle Fork Willamette subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches due to climate change (a major adverse effect) but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 4, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for aquatic and wetland habitat along downstream reaches within the Middle Fork Willamette subbasin. Adding downstream fish passage at Hills Creek and Lookout Point and lamprey passage at Hills Creek would slightly improve foraging opportunities for wildlife species within the subbasin. Adding a WTC tower at Hills Creek and Lookout Point would slightly improve water temperature for salmonids, which are important to piscivorous wildlife. On the other hand, the drawdowns within Hills Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects. There would be potential for moderate adverse effects to wildlife and wildlife habitat at the reservoirs as a result of the drawdowns combined with cumulative effects, particularly climate change. These effects would push an increasing trend toward decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

###### *4.9.2.7.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would affect wildlife and wildlife habitat around the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Coast Fork Willamette subbasin entails decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

With the implementation of Alternative 4, the drawdowns at Cottage Grove and Dorena would make wildlife and wildlife habitat at the reservoirs more susceptible to climate change effects. These drawdowns would potentially cause major adverse effects to wildlife and wildlife habitat at the reservoirs when combined with cumulative effects, particularly climate change. This would push trends toward decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories at the reservoirs.

###### *4.9.2.7.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 4 would not have a more than negligible effect on the general trend of decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches.

#### *4.9.2.8 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Overall, cumulative effects to wildlife and wildlife habitat would be major over the period of analysis. Changes to wildlife and wildlife habitat in terms of biodiversity and suitable habitat availability would be affected by climate change, water withdrawals, and habitat fragmentation due to development. Alternative 5 (as with Alternative 2B) would also have moderate effects to wildlife and wildlife habitat within the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in most subbasins as discussed below. Most notably at Cougar reservoir, because deep fall and spring drawdowns would be included as a part of Alternative 5 (as with Alternative 2B) there would be potential for major effects to aquatic and wetland habitat around the reservoir when combined with climate change effects.

The effects of Alternative 5 when combined with cumulative effects are identical to those of Alternative 2B as presented in Section 4.9.2.4. except that the refined integrated temperature and habitat flow regime (Measure #30b) would be implemented instead of Measure #30a and would yield slightly better survival of ESA-listed salmonids within all WVS tributaries, though it is unknown to what degree. This may improve foraging opportunities for piscivorous wildlife throughout the WVS; however, the improvement would most likely be negligible over what had been presented for Alternative 2B. Cumulative effect summaries for Alternative 5 by subbasin are provided below.

##### *4.9.2.8.1 Santiam Subbasin*

As a result of cumulative effects within the Santiam subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Detroit and Green Peter, which would affect aquatic and wetland habitat around the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Santiam subbasin entails decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories, which would have a major adverse effect to wildlife and wildlife habitat within the subbasin.

With the implementation of Alternative 5, gravel augmentation downstream of Big Cliff and Foster Dams would slightly improve conditions for aquatic and wetland habitat along downstream reaches within the Santiam subbasin. Adding lamprey passage at Green Peter and downstream fish passage at Detroit and Foster would slightly improve foraging opportunities for wildlife species within the subbasin. Adding a WTC tower at Detroit would slightly improve water temperature for salmonids, which are important to piscivorous wildlife. On the other hand, the drawdowns within Green Peter and Detroit would further exacerbate cumulative effects. Particularly at Green Peter, where a deep fall drawdown would be implemented, there would be potential for major effects to aquatic and wetland habitat when combined with cumulative effects, particularly climate change. This major adverse effect would entail an increasing trend toward decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

#### *4.9.2.8.2 Long Tom Subbasin*

As a result of cumulative effects within the Long Tom subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Fern Ridge dam and reservoir; however, there would be warmer drier summers. In addition, there would be decreased overall reservoir elevations at Fern Ridge, which would affect wildlife and wildlife habitat at the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Long Tom subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories and this would constitute a major adverse effect within the Long Tom subbasin. Alternative 5 would not change operations at Fern Ridge and therefore would not affect changes within the subbasin.

#### *4.9.2.8.3 McKenzie Subbasin*

As a result of cumulative effects within the McKenzie subbasin, there would be an increase in winter instream flows, both upstream and downstream of Cougar and Blue River dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wildlife and wildlife habitat in the McKenzie subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches due to climate change but would remain largely unchanged around Cougar and Blue River reservoirs as a result of cumulative effects.

With the implementation of Alternative 5, gravel augmentation downstream of Cougar and Blue River dams will slightly improve conditions for aquatic and wetland habitat along downstream reaches within the McKenzie subbasin, which could offset some of the climate change effects in downstream reaches. At the reservoirs, on the other hand, the drawdowns at Cougar and Blue River would make aquatic and wetland habitat around the reservoirs more susceptible to climate change effects. Particularly at Cougar, where deep fall and spring drawdowns would be implemented, there would be potential for major adverse effects to wildlife and wildlife habitat when combined with cumulative effects, particularly climate change. This would push trends toward decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

#### *4.9.2.8.4 Middle Fork of the Willamette Subbasin*

As a result of cumulative effects within the Middle Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the WVS dams and reservoirs, which would lead to higher reservoir elevations during the conservation season. However, these would be offset by warmer drier summers and water withdrawals. The general trend of wildlife and wildlife habitat in the Middle Fork Willamette subbasin would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches due to climate change (a major adverse effect) but would remain largely unchanged around Hills Creek, Lookout Point, and Fall Creek reservoirs as a result of cumulative effects.

With the implementation of Alternative 5, gravel augmentation downstream of the Middle Fork dams will slightly improve conditions for aquatic and wetland habitat along downstream reaches within the Middle Fork Willamette subbasin. Adding downstream fish passage at Lookout Point would slightly improve foraging opportunities for wildlife species within the subbasin. On the other hand, the drawdowns within Hills Creek, Lookout Point, and Fall Creek will further exacerbate the cumulative effects at the reservoirs. There would be potential for major adverse effects to wildlife and wildlife habitat as a result of the drawdowns combined with cumulative effects, particularly climate change. This effect would entail decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

##### *4.9.2.8.5 Coast Fork of the Willamette Subbasin*

As a result of cumulative effects within the Coast Fork Willamette subbasin, there would be an increase in winter instream flows, both upstream and downstream of the Cottage Grove and Dorena dams and reservoirs; however, there would be warmer drier summers. In addition, there would be decreased reservoir elevations at Cottage Grove and Dorena during the conservation season, which would affect wildlife and wildlife habitat at the reservoirs. Therefore, the general trend of wildlife and wildlife habitat in the Coast Fork Willamette subbasin entails decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories.

The implementation of Alternative 5 would not have a more than negligible effect on the general trend of decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories within the Coast Fork Willamette.

##### *4.9.2.8.6 Mainstem Willamette River*

The general trends as a result of the cumulative effects would see an increase in winter inflows and a decrease of instream flows within the Mainstem Willamette River during the conservation season. The implementation of Alternative 5 would not have a more than negligible effect on the general trend of decreases to suitable habitat acreage, degraded water quality, and changes to the seasonality of wildlife life histories along downstream reaches.

## 4.10 AIR QUALITY

This section discusses the cumulative effects on air quality. This includes a discussion of the effects of proposed measures considered alongside applicable cumulative actions, and how each project alternative would cumulatively affect air quality. The geographic scope for air quality would be the same boundary as described in the Affected Environment in Chapter 3, which includes all USACE project locations within the WVS.

### 4.10.1 Cumulative Actions Applicable to Air Quality

Past, present, and reasonably foreseeable future actions that, when considered together with the Proposed Action and alternatives, would have cumulative effects on air quality, include:

- Operation of the WVS dams and supporting structures and facilities;
- Structural improvements to modify existing WVS structures;
- Trap-and-haul fish trucking operation;
- Transportation corridor development;
- RFFA 1, future population growth and accompanying urban, industrial, and commercial development;
- RFFA 4, decarbonizing the energy sector with renewable energy sources;
- RFFA 5, federal and state wildlife and lands management;
- RFFA 7, Tribal, state, and local fish and wildlife improvement; and
- RFFA 9, climate change.

Some of the RFFAs discussed in Section 4.2.3 would not have a cumulative effect on air quality. These include RFFA 2, reduced agricultural production; RFFA 3, water withdrawals for municipal, industrial, and agricultural uses; RFFA 6, fishery management and killer whales; and RFFA 8, invasive species management. These actions do not contribute to air quality; thus, these RFFAs are not discussed further in this cumulative effects analysis. Other RFFAs could have contributed to cumulative effects for air quality had they occurred at or in close proximity to the WVS dams and reservoirs. These include RFFA 10, mining operations; and RFFA 11, timber and logging industry operations. Mining operations and timber and logging operations are not located within the geographic scope of USACE project locations, and there are no planned projects or projected changes for the foreseeable future. Therefore, these RFFAs are not discussed further in this cumulative effects analysis.

### 4.10.2 Discussion of Cumulative Effects by Measure(s)

This section considers the proposed measures with applicable cumulative actions to determine the potential cumulative effect to air quality. Where possible, the discussion of cumulative effects is grouped by measures that would have similar effects.

#### *4.10.2.1 Construct water temperature control (WTC) towers (#105), Construct structural downstream fish passages (#392), Construct adult fish facilities (AFFs) (#722), and Provide Pacific lamprey passage and infrastructure (#52)*

As discussed in Section 3.10.3.3.1, the magnitude of adverse effects from the construction of WTC towers (#105), structural downstream fish passages (#392), AFFs (#722), and Pacific lamprey passage and infrastructure (#52) would be negligible to minor because additional emissions from truck mileage and generators would not exceed 50% of a federal or state standard and would likely be undetectable compared to the entire geographic region of the WVS. O&M of USACE infrastructure, trap-and-haul fish trucking operations, transportation corridor development, population growth and associated urban landscape development, renewable energy, land management, fish and wildlife management and improvement, and climate change would have a range of similar effects on air quality as the proposed measures.

Structural improvements are already planned to occur under the interim injunction within the WVS at Dexter, Big Cliff, and Cougar Dams. These actions and others would potentially include construction upgrades at all dams and could potentially adversely affect air quality with additional construction vehicles and/or modifications to fish trucking and generator usage. O&M of USACE infrastructure and trap-and-haul fish trucking operations would continue to contribute diesel emissions into the atmosphere (as discussed in Chapter 3). Population growth and continued development would additively contribute to an increase in air emissions, as more construction activities, paved roadways, and urban sprawl would lead to more personal vehicles, vehicle miles traveled, buses, construction vehicles and equipment, and shipping trucks throughout the WRB.

Urban development would also greatly reduce natural spaces that do not contribute air emissions, and in fact reduce some criteria pollutants through plant uptake. Climate change may also adversely affect air quality through an increased future incidence of forest fires; combustion of woody matter generates criteria pollutants such as carbon monoxide, particulate matter, volatile organic compounds, and nitrogen oxides, the latter two of which are ozone precursors. Some of these adverse effects would be minimized by actions to conserve and protect natural resources in the WRB, such as wildlife refuges, preserves, national forests, and through other land management strategies, such as the use of prescribed fire to prevent the accumulation of excessive fuel loads. These actions have already been undertaken at many project sites through the creation of parks, recreational reservoirs and beaches, and wildlife trails.

Renewable energy sources, such as wind turbines, solar arrays, and geothermal power, could potentially offset or counteract these adverse effects to some extent by producing clean energy without emitting criteria pollutants into the atmosphere. Several USACE project locations feature dams that produce hydropower, another form of renewable, clean energy; however, there are no proposed renewable energy projects within the counties representing the WRB. Overall, when considered together with the proposed measures, applicable cumulative actions would create adverse, additive, negligible to minor cumulative effects to air quality.

#### *4.10.2.2 Restore upstream and downstream passage at drop structures (#639)*

As discussed in Section 3.10.3.3.2, the magnitude of beneficial effects from restoring upstream and downstream passage at drop structures (#639) would be minor because fish passage measures would allow fish to pass through the Fern Ridge Dam without being trapped or hauled, thereby reducing the amount of total fish trucking mileage and associated air emissions. Renewable energy, land management, and fish and wildlife management and improvement would have a range of similar effects on air quality as the drop structures. Renewable energy sources, such as wind turbines, solar arrays, and geothermal power, produce clean energy without emitting criteria pollutants into the air. Several USACE project locations feature dams that produce hydropower, another form of renewable, clean energy; however, there are no proposed renewable energy projects within the counties representing the WRB. Actions to conserve and protect natural areas and resources, such as wildlife refuges, preserves, national forests, and other wildlife habitats and public lands, would preserve natural trees, shrubs, and other vegetation that do not contribute to air emissions. This vegetation would actually decrease the amount of some criteria pollutants in the air through plant uptake. Overall, when considered together with the proposed measures, applicable cumulative actions would result in beneficial, additive, and negligible to minor cumulative effects to air quality, which as noted in the Air Quality Affected Environment section (3.10.2.2), is generally relatively good.

#### *4.10.2.3 Deeper fall reservoir drawdowns for fish passage (#40) and Spring reservoir drawdown for downstream fish passage (#720)*

As discussed in Section 3.10.3.3.3, the magnitude of adverse effects from deeper fall reservoir drawdowns (#40) and spring reservoir drawdowns (#720) would be negligible because atmospheric conditions would not be conducive to producing fugitive dust emissions over the relatively short time span of the drawdowns. Therefore, reservoir drawdowns would also contribute a negligible cumulative effect to air quality, and may be dismissed from further analysis.

### 4.10.3 Discussion of Cumulative Effects by Alternative

This section analyzes the relevant cumulative actions by alternative to determine the potential cumulative effects to air quality.

#### *4.10.3.1 No Action Alternative*

The NAA would include an adaptive hatchery program (#719), the continued operation of AFFs, and the maintenance of existing and new fish release sites (#726). Because these activities are already occurring and would not change the total truck mileage or number of generators from current levels, their contribution to cumulative effects would be negligible. The NAA would also include the Fall Creek Reservoir drawdown which would be negligible in magnitude (as discussed in Section 3.10.3.3.3 and 3.10.3.4). None of the cumulative actions would have similar effects; as such, any contribution to cumulative effects would be negligible.

#### *4.10.3.2 Alternative 1. Improve Fish Passage Through Storage-Focused Measures*

Under Alternative 1, total fish trucking mileage and the number of generators would increase, but additional associated air emissions would not exceed 50% of a federal or state standard and would likely be undetectable compared to the entire geographic region of the WVS. As discussed above in Sections 4.10.2.1 and 4.10.2.2, these measures would contribute beneficial and adverse, additive, negligible to minor cumulative effects. Alternative 1 would have the same general cumulative effect as all other alternatives. Any new structures under Alternative 1 would represent a very small contribution to the overall cumulative effects compared to all cumulative actions and within the WRB as a whole.

#### *4.10.3.3 Alternative 2A. Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam)*

Under Alternative 2A, total fish trucking mileage and the number of generators would increase, but additional associated air emissions would not exceed 50% of a federal or state standard and would likely be undetectable compared to the entire geographic region of the WVS. As discussed above in Sections 4.10.2.1 and 4.10.2.3, these measures would contribute adverse, additive, negligible to minor cumulative effects. Alternative 2A would have the same general cumulative effect as all other alternatives. Any new structures under Alternative 2A would represent a very small contribution to the overall cumulative effects compared to all cumulative actions and within the WRB as a whole.

#### *4.10.3.4 Alternative 2B. Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Under Alternative 2B, the cumulative effects to air quality would be the same as those described under Alternative 2A. As discussed above in Sections 4.10.2.1 and 4.10.2.3, these measures would contribute adverse, additive, negligible to minor cumulative effects. Alternative 2B would have the same general cumulative effect as all other alternatives. Any new structures under Alternative 2B would represent a very small contribution to the overall cumulative effects compared to all cumulative actions and within the WRB as a whole.

#### *4.10.3.5 Alternative 3A. Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)*

Under Alternative 3A, total fish trucking mileage and the number of generators would increase, but additional associated air emissions would not exceed 50% of a federal or state standard and would likely be undetectable compared to the entire geographic region of the WVS. As discussed above in Sections 4.10.2.1 and 4.10.2.3, these measures would contribute adverse, additive, negligible to minor cumulative effects. Alternative 3A would have the same general cumulative effect as all other alternatives. Any new structures under Alternative 3A would represent a very small contribution to the overall cumulative effects compared to all cumulative actions and within the WRB as a whole.

#### *4.10.3.6 Alternative 3B. Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Under Alternative 3B, the cumulative effects to air quality would be the same as those described under Alternative 3A. As discussed above in Sections 4.10.2.1 and 4.10.2.3, these measures would contribute adverse, additive, negligible to minor cumulative effects. Alternative 3B would have the same general cumulative effect as all other alternatives. Any new structures under Alternative 3B would represent a very small contribution to the overall cumulative effects compared to all cumulative actions and within the WRB as a whole.

#### *4.10.3.7 Alternative 4. Improve Fish Passage with Structures-Based Approach*

Under Alternative 4, total fish trucking mileage and the number of generators would increase, but additional associated air emissions would not exceed 50% of a federal or state standard and would likely be undetectable compared to the entire geographic region of the WVS. As discussed above in Sections 4.10.2.1 and 4.10.2.2, these measures would contribute beneficial and adverse, additive, negligible to minor cumulative effects. Alternative 4 would have the same general cumulative effect as all other alternatives. Any new structures under Alternative 4 would represent a very small contribution to the overall cumulative effects compared to all cumulative actions and within the WRB as a whole.

#### *4.10.3.8 Alternative 5. Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Under Alternative 5, the cumulative effects to air quality would be the same as those described under Alternative 2B. As discussed above in Sections 4.10.2.1 and 4.10.2.3, these measures would contribute adverse, additive, negligible to minor cumulative effects. Alternative 5 would have the same general cumulative effect as all other alternatives. Any new structures under Alternative 5 would represent a very small contribution to the overall cumulative effects compared to all cumulative actions and within the WRB as a whole.

### 4.10.4 Summary

In summary, the cumulative effects of each of the alternatives would have similar additive, negligible to minor effects. Any cumulative effect to air quality from any alternative would represent a very small contribution to the overall cumulative effects compared to all cumulative actions and within the WRB as a whole.

## 4.11 SOCIOECONOMIC RESOURCES

This section discusses the cumulative effects on socioeconomic resources. This includes a discussion of the effects of proposed measures considered alongside applicable cumulative actions, and how each project alternative would cumulatively affect socioeconomic resources. The ROI for socioeconomic resources would be the same boundary as described in the Affected Environment in Chapter 3, or Lane, Linn, and Marion counties.

### 4.11.1 Cumulative Actions Applicable to Socioeconomic Resources

Past, present, and reasonably foreseeable future actions that, when considered together with the Proposed Action and alternatives, would have cumulative effects on socioeconomic resources, include:

- Construction of the WVS and other dams and supporting structures in the WRB;
- WRB population growth and development;
- Transportation corridor development;
- Floodplain development;
- Logging and mining within the watershed;
- Commercial and recreational fish harvesting;
- Water withdrawals for irrigation, municipal, and industrial uses;
- Modifications of existing WVS structures at Dexter, Big Cliff, and Cougar;
- RFFA 1, future population growth and accompanying urban, industrial, and commercial development;
- RFFA 2, reduced agricultural production;
- RFFA 3, water withdrawals for municipal, industrial, and agricultural uses;
- RFFA 5, federal and state wildlife and lands management;
- RFFA 7, Tribal, State, and local fish and wildlife improvement;
- RFFA 8, invasive species management;
- RFFA 9, climate change;
- RFFA 10, mining operations; and
- RFFA 11, timber and logging industry operations.

Some of the other RFFAs discussed in Section 4.2.3 would not affect socioeconomic resources and therefore are not discussed further in these cumulative effects analysis. These include RFFA 4, decarbonizing the energy sector with renewable energy sources; and RFFA 6, fishery management and killer whales.

### 4.11.2 Discussion of Cumulative Effects by Measure(s)

This section considers the proposed measures with applicable cumulative actions to determine the potential cumulative effect to socioeconomic resources. Where possible, the discussion of cumulative effects is grouped by measures that would have similar effects.

#### *4.11.2.1 Construction, Operation, Management, Rehabilitation, and Replacement of Structural Improvements*

Construction, modification, operation and maintenance of all 13 proposed structural measures in conjunction with the past, present, and RFFAs would cumulatively affect labor and earnings; population and housing; recreational value; quality of life for local residents; low-income populations; and non-use and existence values.

##### *4.11.2.1.1 Labor and Earnings*

As discussed in Sections 3.11.2.4.1, the magnitude of beneficial effects to labor and earnings within the ROI from the construction of structural improvements would be negligible to minor depending upon the scale of the required capital expenditures which would occur within the ROI under each alternative. These revenues would likely result in the creation of a relatively small number of construction jobs in the short and medium term sourced from within the ROI. Construction workers employed on the project would also likely increase revenues at local retail stores and restaurants, resulting in induced (i.e., third-order) economic benefits. Construction materials would also be sourced from local vendors whenever possible and would likely contribute to the indirect creation of jobs within the ROI.

The results of modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 10, mining operations; and RFFA 11, timber and logging industry operations would have similar beneficial effects on socioeconomic resources as the construction of structural measures. These actions would provide additional influxes of capital into the ROI, prompting direct, indirect, and induced creation of jobs. When considered cumulatively, these benefits can be considered interactive; each action introduces additional revenue streams into the ROI and synergistically increases the overall level of consumer demand, thereby stimulating further job and revenue growth. As such, the magnitude of these cumulative effects would be considered minor to moderate in the short and medium term given the third order increases in consumer demand throughout the ROI. The magnitude of the benefits would be contingent on the level of expenditures and the timing associated with each of the actions in relation with the proposed measures. In particular, effects would be greatest if large expenditures associated with the cumulative actions listed above occurred at the same time as more expensive, medium-term measures (e.g., construction of WTC tower or structural downstream passage).

#### *4.11.2.1.2 Population and Housing*

As discussed in 3.11.2.4.1, the in-migration of workers to support the construction, operation, and maintenance of structural measures would contribute negligible to minor adverse effects on housing in the short and medium term. In addition to RFFA 1, future population growth and accompanying urban, industrial, and commercial development, other cumulative actions that require specialized contractors to migrate to the ROI would have cumulative effects on population and housing. These cumulative actions include construction of the WVS and other dams, reservoirs, and supporting structures in the WRB; transportation corridor development; floodplain development; modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; RFFA 10, mining operations; and RFFA 11, timber and logging industry operations. These actions would contribute additive cumulative effects and would increase demand on housing if many of the actions occurred at the same time as medium-term structural measures (e.g., construction of WTC towers). However, given the existing housing vacancies within the ROI, housing would likely continue to operate below capacity and therefore cumulative, additive effects would be minor in the short and medium term.

#### *4.11.2.1.3 Recreational Value*

As discussed in Section 3.11.2.4.1, adverse effects to recreational quality at recreational sites in the vicinity of project activities from construction-related noise, emissions, and congestion would be negligible to moderate in the short and medium term. The proposed structural measures in combination with floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; and the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar would also add noise, emissions, and congestion and therefore have adverse effects to the recreational quality at recreational sites in the vicinity of project activities. The cumulative effects would be additive and negligible to moderate in the short and medium term. The magnitude of the effect would depend on the proximity of the cumulative actions and proposed structural measures to the recreational site or the recreationist, as well as the timing of the projects. For example, if construction of medium-term proposed structural measures (e.g., Structural improvements to reduce TDG) occurred at the same time as modifications of existing WVS structures at Dexter, Big Cliff, and Cougar, cumulative effects would be moderate in the medium term.

The proposed structural measures would have indirect, adverse effects to the quality of recreational fishing in reservoirs and on rivers for some species due to increased turbidity from suspended sediment associated with construction measures. As discussed in Appendices F1 and F2 (Qualitative Assessment of Climate Change Impacts and Supplemental Climate Change Information, respectively), climate change is expected to result in wetter winters (where more precipitation falls as rain rather than snow), less snowpack, drier summers, increased air and water temperatures, lower summer flows, increased reservoir evaporation, and increased wildfire intensity and frequency in the WRB. As such, climate change would have additive, minor, cumulative, indirect, adverse effects in the long term to recreational quality, and therefore recreational users' contribution to the economy of the ROI through expenditures in support of recreational activities; as well as induced effects of retail revenue streams.

The proposed structural measures would also have long-term, indirect, minor, beneficial effects on recreational fishing and visitation within the ROI. Floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; and RFFA 9, climate change would have interactive, countervailing cumulative effects to recreational quality in the form of construction-related noise, congestion, turbidity, and emissions. These cumulative actions would reduce both the value of affected reservoirs as well as their visitation rates – thereby reducing expenditures within the ROI and ultimately consumer demand. Although the majority of adverse cumulative effects would likely be confined to the construction phases of each project, overlapping project timelines or vicinities could potentially extend effects over a larger period of time and compound adverse effects within smaller portions of the ROI. As such these cumulative effects would be considered interactive and countervailing; and the overall indirect, long-term beneficial effect on recreational fishing would be negligible.

#### *4.11.2.1.4 Quality of Life*

Adverse effects to quality of life of residents in the vicinity of project would be negligible to moderate in magnitude in the short and medium term. The same factors that degrade recreational quality – construction-related noise, emissions, and congestion – would similarly be nuisances to local residents and reduce the overall quality of life. The proposed structural measures in combination with floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; and the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar would also add noise, emissions, and congestion and therefore have adverse effects to the quality of life for nearby residents. The use of local roadways during work periods for transport of workers and materials associated with the above-listed cumulative actions would further temporarily increase traffic levels and average length of transit for nearby communities, and could reduce resident access to community resources such as places of worship, recreational facilities, and healthcare. The cumulative effects would be additive and negligible to moderate in the short and medium term. The magnitude of the effect would ultimately depend on the timing and proximity of the projects to residents – especially in the towns of Detroit, Lowell, Veneta, and Sweet Home that are on the shores of Detroit, Dexter, Fern Ridge, and Foster reservoirs, respectively. For example, if construction of medium-term proposed structural measures (e.g., Structural improvements to reduce TDG at Dexter, as is the case under Alternatives 1 and 4) occurred at the same time as modifications of existing WVS structures at Dexter, cumulative effects to the quality of life of Lowell residents would be moderate in the medium term.

#### *4.11.2.1.5 Low Income Populations*

Low-income populations in Lane, Linn, and Marion counties that are hired to work on could experience negligible to minor health benefits through economic pathways in the short and medium term. There may also be negligible to minor adverse effects to the physical health and well-being of low-income communities (from increased air emissions and noise levels) that are hired to work at the sites for the duration of these projects. Negligible to minor, adverse and beneficial additive, cumulative effects to the health of low-income populations would occur in the short and medium term when the proposed structural measures are considered in combination with floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; and the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar.

As discussed in Section 3.11.2.4.1, the short- and medium-term construction projects under the proposed action and alternatives would not affect any ongoing shortages for low-income populations or the availability of general or affordable housing within the ROI. However, if the proposed structural measures occurred at the same time as some or all of the other cumulative construction actions that would create jobs and an in-migration of workers (i.e., modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 10 mining operations; and RFFA 11 timber and logging industry), rent prices could increase and the availability of affordable (and general) housing could decrease. Oregon now has rent control that limits rent increases for existing tenants. Rent cannot be increased during any 12-month period above the existing rent in an amount greater than 7% plus the consumer price index from the previous calendar year (OSB 2019). There are a total of approximately 21,121 available housing units in the ROI; and about half of those are considered affordable housing (USCB 2019c; State of Oregon 2022). Although housing supplies would likely expand with new development, it is possible that stresses on the existing housing supply would increase housing prices and potentially displace low-income residents from housing and access to community resources. Depending on the timing of the proposed structural measures and the cumulative actions, cumulative, additive effects to housing availability and rent prices would be negligible to minor in the short and medium term.

#### *4.11.2.2 Alteration of Outflows and Reservoir Levels*

Measures that would alter flows and reservoir levels in conjunction with past, present, and RFFAs would cumulatively affect recreational value; agricultural irrigation and municipal and industrial (M&I) use; and the quality of life for nearby residents.

##### *4.11.2.2.1 Recreational Value*

As discussed in Section 3.11.2.4.2, reservoir drawdowns would have short- and long-term recurring adverse effects on recreational value that would range from minor to major. Reservoir drawdowns would reduce water levels and substantially decrease recreational use and the recreational value of the reservoir, indirectly affecting socioeconomic resources throughout the ROI. Reservoir drawdowns during the primary spring/summer recreational season (measure #720 and #714) would reduce recreational use of water-based activities, value, and quality at affected reservoirs, potentially reducing visitation. Recreational users contribute to the economy of the ROI through the expenditure of funds in support of their activity of choice, such as specialized sporting equipment, licensing, hiring of guides, fuel, food, and lodging; reduction of visitation would subsequently reduce this revenue stream within the ROI. RFFA 3, water withdrawals for municipal, industrial, and agricultural uses would have similar short-term effects on recreational value. Both would reduce recreational access and quality of reservoirs, thereby reducing visitation and its associated revenues. However, it is important to note that the allocation of agricultural, municipal, and industrial water demand is much smaller than that required for fish and wildlife management and these additional drawdowns would only marginally affect reservoir levels. RFFA 9, climate change could exacerbate short-term effects from sediment transport during drawdowns, as increased wildfire ash, HABs, and upstream erosion would cause erosion in reservoirs and would further increase turbidity and decrease water quality downstream; affecting the recreational experience and visitation in both reservoirs and rivers. The overall water level could be further reduced in the long term.

In addition to RFFA 3, water withdrawals for municipal, industrial, and agricultural uses, RFFA 1, future population growth and accompanying urban, industrial, and commercial development; and RFFA 9, climate change would also have adverse long-term effects to recreational value. RFFA 1 would likely increase visitation of recreational reservoirs, but could potentially degrade the quality of recreational visitation due to crowding and congestion. Lower recreational quality could lower the amount of revenues expected from each visitor, as well as the probability of repeat visits. Climate change would contribute to cumulative effects for socioeconomic resources through longer and more arid drought seasons and smaller snowpacks, lowering reservoir levels and reducing recreational visitation. Increased water temperatures as a result of climate change could also reduce the habitat suitability of the ROI for recreationally fished salmonids, which are major drivers of recreational visitation.

As discussed in Section 3.11.2.4.2, reservoir drawdowns would have long-term, indirect beneficial effects to socioeconomic resources with the improvement of downstream riverine habitat quality for ESA-listed fish species, recreational fisheries, and water quality throughout the ROI. (Note that reservoir visitation provides a far greater proportion of recreational revenues within the ROI than riverine visitation.) RFFA 5, federal and state wildlife and lands management; RFFA 7, Tribal, state and local fish and wildlife improvement; and RFFA 8, invasive species management would also improve the overall quality of fish habitat within the ROI, which could potentially offset some of the adverse effects of climate change on fishery quality and subsequent recreational visitation in the long term.

Overall, cumulative, additive adverse effects on the recreational value would be minor to major in the short and long term (recurring). RFFA 9, climate change; the timing of RFFA 3, water withdrawals for municipal, industrial, and agricultural uses; and the timing and number of reservoir drawdowns for juvenile fish passage would be the main indicators of the magnitude of effects on recreational value under each alternative.

##### *4.11.2.2.2 Irrigation and M&I Use*

As discussed in Section 3.11.2.4.2, spring drawdowns would result in major adverse socioeconomic effects from reduced water availability for agricultural irrigation and M&I purposes. Fall drawdowns would occur during periods with minimal WVS water use and would only result in negligible to minor socioeconomic effects. As such, adverse effects attributable to water supply would range from negligible to major in the short term and would recur in the long term.

RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change would exacerbate these effects. As noted above, the allocation of agricultural, municipal, and industrial water demand is much smaller than that required for fish and wildlife management and these additional drawdowns would only marginally affect reservoir levels. As such, cumulative, additive effects from RFFA 3, RFFA 9, and spring drawdowns would be major due to reduced water availability for agricultural irrigation and M&I purposes. Cumulative, additive effects from RFFA 3, RFFA 9, and fall drawdowns would be negligible to minor. Overall, cumulative, additive adverse effects attributable to water supply would range from negligible to major in the short term and would recur in the long term.

##### *4.11.2.2.3 Quality of Life*

As discussed in Section 3.11.2.4.2, the loss of surface water during reservoir drawdowns would have minor to moderate short- and long-term effects to the viewshed and therefore quality of life of nearby residents – especially in the town of Detroit, which is located on the shores of Detroit Dam and Reservoir. (The towns of Lowell, Veneta, and Sweet Home on the shores of Dexter, Fern Ridge, and Foster Dams, respectively, would not be affected because drawdowns are not proposed at these locations under any of the alternatives). RFFA 3, water withdrawals for municipal, industrial, and agricultural uses would further decrease the water level and have similar short-term effects on the viewshed. RFFA 9, climate change could exacerbate short-term effects from sediment transport during drawdowns, as increased wildfire ash, HABs, and upstream erosion would cause erosion in reservoirs and would further increase turbidity and decrease water quality downstream; affecting the aesthetics of both reservoirs and rivers. Less snowpack would decrease spring reservoir inflows, and drier, hotter summers (in terms of both air and water temperatures) would increase evaporation rates and further limit water quantity and further reduce the overall water level in the long term. As such, cumulative, additive adverse effects to the quality of life from the proposed reservoir drawdowns, RFFA 3, and RFFA 9 would be minor to moderate in the short and long term.

#### ***4.11.2.3 Non-Use and Existence Values***

As discussed in 3.11.2.4.3, implementation of all the proposed measures would help preserve the existence value (the benefit people receive from knowing that it exists, or its intrinsic value) of the UWR Chinook salmon and UWR steelhead and therefore have long-term, minor beneficial effects to society. Without these proposed measures, these species – or more precisely, their respective evolutionarily significant units (ESUs) and distinct population segments (DPSs) – could cease to exist in the WRB; the resulting loss of their existence values would be major and adverse. The modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; RFFA 5, federal and state wildlife and lands management; RFFA 7, Tribal, State and local fish and wildlife improvement; and RFFA 8, invasive species management would further benefit fish habitat and populations and generally help to avoid jeopardizing the continued existence of the UWR Chinook salmon and UWR steelhead.

However, the remaining past, present, and RFFAs listed in 4.11.1 would be interactive and countervailing, working against the proposed measures. construction of the WVS and other dams, reservoirs, and supporting structures in the WRB ; WRB population growth and development; transportation corridor development; floodplain development; commercial and recreational fish harvesting; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 9, climate change; RFFA 10, mining operations; and RFFA 11, timber and logging industry operations could affect turbidity and water quality and therefore fish habitat. RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change could further affect water quantity. These would further jeopardize the existence of the ESA-listed fish and therefore overall cumulative long-term benefits would be negligible.

### 4.11.3 Discussion of Cumulative Effects by Alternative

This section analyzes the relevant cumulative actions by alternative to determine the potential cumulative effects to socioeconomic resources.

#### *4.11.3.1 No Action Alternative*

Under the NAA, current actions within the WVS and the conditions that would result from continued O&M and configuration of the WVS under existing management would persist. As described above in 4.11.2.1, the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 10, mining operations; and RFFA 11, timber and logging industry operations would also provide influxes of capital into the ROI and prompting the creation of jobs and a small in-migration of specialized contractors. These cumulative effects to labor and earnings (including low-income populations) would be synergistic if they occur at the same time and thus would create minor, beneficial cumulative effects in the short and medium term. Cumulative effects to population and housing would be additive but also minor in the short and medium term.

The continued O&M structural measures in combination with floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; and the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar would also add noise, emissions, and congestion and therefore have adverse effects to the recreational quality at recreational sites in the vicinity of project activities as well as to the quality of life of nearby residents. The cumulative effects would be additive and negligible in the short and medium term.

The Fall Creek drawdown would occur annually under the NAA. RFFAs 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 3, water withdrawals for municipal, industrial, and agricultural uses; and RFFA 9, climate change would further decrease the recreational quality of visits due to crowding and congestion. The visual effects from the drawdowns and climate change would affect both the quality of the recreational experience as well as the quality of life of nearby residents. Lower recreational quality could lower the amount of revenues expected from each visitor, as well as the probability of repeat visits. Benefits from RFFA 5, federal and state wildlife and lands management; RFFA 7, Tribal, state and local fish and wildlife improvement; and RFFA 8, invasive species management would also improve the overall quality of fish habitat within the ROI, which could potentially offset some of the adverse effects of climate change on fishery quality and subsequent recreational visitation in the long term. But overall, cumulative, additive effects to recreational value and quality of life would be minor and additive in the short and long term (recurring).

RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change would exacerbate effects from reduced water availability to agricultural irrigation and M&I use from the Fall Creek drawdown. As noted above, the allocation of agricultural, municipal, and industrial water demand is much smaller than that required for fish and wildlife management and these additional drawdowns would only marginally affect reservoir levels. The Fall Creek drawdown occurs in the autumn or during periods with minimal WVS water use. As such, cumulative, additive effects from RFFA 3, RFFA 9, and the Fall Creek Drawdown would be negligible in the short and long-term (recurring).

As discussed in 3.11.2.4.3, without the proposed measures under the action alternatives, the evolutionarily significant units (ESUs) and distinct population segments (DPSs) of the UWR Chinook salmon and UWR steelhead could, quite literally, cease to exist in the WRB; the resulting loss of their existence values would be major and adverse. Overall, as discussed above in 4.11.2.3, most of the cumulative actions would further jeopardize the existence of these fish and therefore overall cumulative effects would be major and adverse in the long term.

#### *4.11.3.2 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Alternative 1 consists of structural improvements and alteration of reservoir outflows measures, which maximize refill volumes of spring conservation pools at WVS reservoirs in support of improved survival of ESA-listed fish species, in addition to all other authorized project purposes of the structures. Three WTC towers (#105), three downstream passage structures (#639, #52, and #392), and two AFFs (#722) would be constructed, affecting five project locations at Dexter, Detroit, Green Peter, Lookout Point, and Foster Dams. Alternative 1 would have similar effects to socioeconomic resources as Alternative 4, and would have substantially more beneficial short- and medium-term effects to labor and earnings and more adverse effects to quality of life (and less adverse short and long-term recurring effects to recreational value and M&I use and irrigation) than Alternatives 2A, 2B, 3A, 3B, and 5.

As described above in 4.11.2.1, the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 10, mining operations; and RFFA 11, timber and logging industry operations would also provide influxes of capital into the ROI and prompt the creation of jobs and a small in-migration of specialized contractors. Construction expenditures associated with Alternative 1 are expected to total approximately $1.8B over the life of the project – the second highest of the alternatives. As such, these cumulative effects to labor and earnings (including low-income populations) would be synergistic if they occur at the same time and thus would create moderate, beneficial cumulative effects in the short and medium term. Cumulative effects to population and housing would be additive and minor in the short and medium term.

Construction of the structural measures in combination with floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; and the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar would also add noise, emissions, and congestion and therefore have adverse effects to the recreational quality at recreational sites in the vicinity of project activities, as well as to the quality of life of nearby residents. The magnitude of effects would depend on the proximity of the cumulative actions and proposed structural measures to the recreational site or the recreationist or the resident, as well as the timing of the projects. For example, if the construction of structural improvements to reduce TDG at Dexter (#174) under Alternative 1 occurs at the same time as modifications of existing WVS structures at Dexter, cumulative effects to the quality of life from noise, emissions, and congestion to the residents of Lowell would be more severe than if they occurred consecutively. As such, cumulative effects to recreational value and quality of life would be moderate and additive under Alternative 1 and would occur in the short and medium term.

The Fall Creek drawdown would also occur annually under Alternative 1. RFFA 1, future population growth and accompanying urban, industrial, and commercial development would further decrease the recreational quality of visits due to crowding and congestion. The visual effects from drawdowns, RFFA 3, water withdrawals for municipal, industrial, and agricultural uses, and RFFA 9, climate change would affect both the quality of the recreational experience as well as the quality of life of nearby residents (though, there is not a city on the shores of Fall Creek). Lower recreational quality could lower the amount of revenues expected from each visitor, as well as the probability of repeat visits. Benefits from RFFA 5, federal and state wildlife and lands management; RFFA 7, Tribal, state, and local fish and wildlife improvement; and RFFA 8, invasive species management would improve the overall quality of fish habitat within the ROI, which could potentially offset some of the adverse effects of climate change on general fishery quality and subsequent recreational visitation in the long term. But overall, cumulative, additive effects to recreational value and quality of life would be minor and additive in the short and long term (recurring).

As discussed in 3.11.2.6.2, the alteration of outflows and reservoir levels under Alternative 1 would have beneficial, moderate effects on water supply in the short and long term. One drawdown during the fall at one location (Fall Creek) would have negligible, short- and long-term recurring adverse effects to water supply. RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change would offset these benefits and have countervailing cumulative effects. As such, overall cumulative effects on M&I use and agricultural irrigation from the proposed measures, RFFA 3, and RFFA 9 would be beneficial and minor in the short and long term (recurring).

As discussed in 3.11.2.4.3, the proposed measures would help preserve the existence value of the UWR Chinook salmon and UWR steelhead and would have long-term, minor, beneficial effects. As discussed above in 4.11.2.3, most of the past, present, and RFFAs would be interactive and countervailing, working against the proposed measures. These would further jeopardize the existence of the ESA-listed fish and therefore overall cumulative, long-term benefits to the existence value of these ESA-listed fish would be negligible.

#### *4.11.3.3 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Under Alternative 2A, fewer construction and infrastructure improvement activities would be implemented compared to Alternative 1 and would impact fewer project locations. Alternative 2A would have similar effects to socioeconomic resources as Alternatives 2B and 5 and would have effects of substantially lower magnitude than Alternatives 1, 3A, 3B and 4.

As described above in 4.11.2.1, the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 10, mining operations; and RFFA 11, timber and logging industry operations would also provide influxes of capital into the ROI and prompt the creation of jobs and a small in-migration of specialized contractors. Construction expenditures associated with Alternative 2A would total only approximately $1.1B, which is almost half of those which would occur under Alternative 1. As such, these cumulative effects to labor and earnings (including low-income populations) would be synergistic, minor, and beneficial in the short and medium term. Cumulative effects to population and housing due to an influx of specialized workers would be additive and minor in the short and medium term.

As described above in 4.11.2.1, construction of the structural measures in combination with floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; and the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar would also add noise, emissions, and congestion and therefore have adverse effects to the recreational quality at recreational sites in the vicinity of project activities as well as to the quality of life of nearby residents. Given the fewer structural measures compared to Alternative 1, cumulative effects to recreational value and quality of life would be minor and additive under Alternative 1 and would occur in the short and medium term.

Under Alternative 2A, a fall drawdown would occur annually at Fall Creek as well as Green Peter. RFFA 1, future population growth and accompanying urban, industrial, and commercial development would further decrease the recreational quality of visits due to crowding and congestion. The visual effects from drawdowns, RFFA 3, water withdrawals for municipal, industrial, and agricultural uses, and RFFA 9, climate change would affect both the quality of the recreational experience as well as the quality of life of nearby residents (though, there are no cities directly on the shores of Fall Creek or Green Peter). Benefits from RFFA 5, federal and state wildlife and lands management; RFFA 7, Tribal, state, and local fish and wildlife improvement; and RFFA 8, invasive species management could potentially offset some of the adverse effects of climate change on general fishery quality and subsequent recreational visitation in the long term. But overall, cumulative, additive effects to recreational value and quality of life would still be minor and additive in the short and long term (recurring).

As discussed in 3.11.2.6.2, the alteration of outflows and reservoir levels from the two drawdowns under Alternative 2A would reduce the availability of water supply for M&I and agricultural users. RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change would further reduce water availability. But, the allocation of agricultural, municipal, and industrial water demand is much smaller than that required for fish and wildlife management and the additional drawdown at Green Peter would only marginally affect reservoir levels. Also, both drawdowns occur in the autumn or during periods with minimal WVS water use. As such, cumulative, additive effects from RFFA 3, RFFA 9, and the Green Peter and Fall Creek drawdowns would be minor in the short and long term (recurring).

As discussed in 3.11.2.4.3, the proposed measures would help preserve the existence value of the UWR Chinook salmon and UWR steelhead and would have long-term, minor, beneficial effects. As discussed above in 4.11.2.3, most of the past, present, and RFFAs would be interactive and countervailing, working against the proposed measures. These would further jeopardize the existence of the ESA-listed fish and therefore overall cumulative, long-term benefits to the existence value of these ESA-listed fish would be negligible.

#### *4.11.3.4 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Under Alternative 2B, the cumulative effects to socioeconomic resources would be very similar as those described under Alternative 2A. Under this alternative, one fewer downstream passage structure would be built (#392), and two additional drawdowns – one in the fall (#40) and one in the spring (#720) – would occur at Cougar.

As described above in 4.11.2.1, the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 10, mining operations; and RFFA 11, timber and logging industry operations would also provide influxes of capital into the ROI and prompt the creation of jobs and a small in-migration of specialized contractors. Alternative 2B is $52M lower in construction expenditures than Alternative 2A, but overall effects would be the same as Alternative 2A. Cumulative effects to labor and earnings (including low-income populations) would be synergistic, minor, and beneficial in the short and medium term. Cumulative effects to population and housing due to an influx of specialized workers would be additive and minor in the short and medium term.

As described above in 4.11.2.1, construction of the structural measures in combination with floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; and the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar would also add noise, emissions, and congestion and therefore have adverse effects to the recreational quality at recreational sites in the vicinity of project activities as well as to the quality of life of nearby residents. Despite one fewer structural downstream fish passage compared to Alternative 2A, effects to recreational value and quality of life would also be minor and additive in the short and medium term.

Under Alternative 2B, a fall drawdown would occur annually at Fall Creek, Green Peter, and Cougar; a spring drawdown would also occur at Cougar. The spring drawdowns at Cougar would reduce recreational expenditures at this reservoir throughout the life of the project due to decreased recreational quality during the spring/summer recreation season. However, Cougar is one of the least visited reservoirs of the 13 reservoirs; and visitors spend the least amount of dollars per visit at this reservoir (USACE 2019e). RFFA 1, future population growth and accompanying urban, industrial, and commercial development would further decrease the recreational quality of visits due to crowding and congestion. The visual effects from drawdowns; RFFA 3, water withdrawals for municipal, industrial, and agricultural uses; and RFFA 9, climate change would affect both the quality of the recreational experience as well as the quality of life of nearby residents (though, there are no cities directly on the shores of Fall Creek, Green Peter, or Cougar). Benefits from RFFA 5, federal and state wildlife and lands management; RFFA 7, Tribal, state, and local fish and wildlife improvement; and RFFA 8, invasive species management could potentially offset some of the adverse effects of climate change on general fishery quality and subsequent recreational visitation in the long term. Overall, cumulative, additive effects to recreational value and quality of life would still be minor and additive in the short and long term (recurring).

As discussed in 3.11.2.6.2, the alteration of outflows and reservoir levels under Alternative 2B would reduce the availability of water supply for M&I and agricultural users. RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change would further reduce water availability. But, the allocation of agricultural, municipal, and industrial water demand is much smaller than that required for fish and wildlife management. While three drawdowns occur in the autumn or during periods with minimal WVS water use, the spring drawdown at Cougar would reduce the recharge ability of WVS system-wide and occur during periods of highest use for both agricultural irrigation and M&I purposes. As such, cumulative, additive effects from RFFA 3, RFFA 9, and the four total drawdowns would be minor to moderate in the short and long term (recurring).

As discussed in 3.11.2.4.3, the proposed measures would help preserve the existence value of the UWR Chinook salmon and UWR steelhead and would have long-term, minor, beneficial effects. As discussed above in 4.11.2.3, most of the past, present, and RFFAs would be interactive and countervailing, working against the proposed measures. These would further jeopardize the existence of the ESA-listed fish and therefore overall cumulative, long-term benefits to the existence value of these ESA-listed fish would be negligible.

#### *4.11.3.5 Alternative 3A – Operations-Focused Fish Passage Alternative*

Alternative 3A consists primarily of alteration of outflows and reservoir drawdowns, along with minor structural improvements and maintenance which increase stream flows and enhance fish passage in support of improved survival of ESA-listed fish species.

As described above in 4.11.2.1, the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA, 10 mining operations; and RFFA 11, timber and logging industry operations would also provide influxes of capital into the ROI and prompt the creation of jobs and a small in-migration of specialized contractors. Construction expenditures associated with Alternative 3A would total only approximately $330M, which is only 34 percent of those of Alternatives 2A and 2B. Construction expenditures would be lowest for this alternative, and as such would result in fewer construction and infrastructure improvement activities compared to all other alternatives. As such, cumulative effects to labor and earnings (including low-income populations) would be synergistic, negligible, and beneficial in the short and medium term. Cumulative effects to population and housing would be additive but also minor in the short and medium term.

As discussed in Section 3.11.2.8.2, alteration of outflows and a total of 10 drawdowns at seven reservoirs would likely substantially decrease the recreational expenditures within the ROI. Annual deep spring drawdowns in particular at Cougar, Detroit, and Lookout Point reservoirs would substantially reduce their recreational value during the spring/summer recreation season. RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change would further decrease the recreational quality of visits due to crowding and congestion. The visual effects from the drawdowns and climate change would affect both the quality of the recreational experience as well as the quality of life of nearby residents, in particular for residents of the city of Detroit living along the shores of Detroit Reservoir. Lower recreational quality could lower the amount of revenues expected from each visitor, as well as the probability of repeat visits. Benefits from RFFA 5, federal and state wildlife and lands management; RFFA 7, Tribal, state, and local fish and wildlife improvement; and RFFA 8, invasive species management would also improve the overall quality of fish habitat within the ROI, which could potentially offset some of the adverse effects of climate change on fishery quality and subsequent recreational visitation in the long term. However overall, cumulative, additive effects to recreational value and quality of life would be major and additive in the short and long term (recurring).

As discussed in Section 3.11.2.8.2, alteration of outflows and the drawdowns under Alternative 3A would also significantly reduce the availability of water supply for M&I and agricultural users. The spring drawdowns at Cougar, Detroit, and Lookout Point in particular would reduce the recharge ability of WVS system-wide and occur during periods of highest use for both agricultural irrigation and M&I purposes. RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change would further reduce water availability. As such, cumulative, additive effects from RFFA 3, RFFA 9, and the ten total drawdowns would be major in the short and long-term (recurring).

As discussed in 3.11.2.4.3, the proposed measures would help preserve the existence value of the UWR Chinook salmon and UWR steelhead and would have long-term, minor, beneficial effects. As discussed above in 4.11.2.3, most of the past, present, and RFFAs would be interactive and countervailing, working against the proposed measures. These would further jeopardize the existence of the ESA-listed fish and therefore overall cumulative, long-term benefits to the existence value of these ESA-listed fish would be negligible.

#### *4.11.3.6 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)*

Under Alternative 3B, the cumulative effects to socioeconomic resources would be almost the same as those described under Alternative 3A. Under 3B, spring drawdowns would occur at Green Peter and Hills Creek instead of at Detroit and Lookout Point under Alternative 3A.

As described above in 4.11.2.1, the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 10, mining operations; and RFFA 11, timber and logging industry operations would also provide influxes of capital into the ROI and prompt the creation of jobs and a small in-migration of specialized contractors. Construction expenditures associated with Alternative 3B would total approximately $415, or $85M in additional construction and maintenance expenditures compared to Alternative 3A. Overall cumulative effects to labor and earnings (including low-income populations) would be the same as under Alternative 3A, or synergistic, negligible, and beneficial in the short and medium term. Cumulative effects to population and housing would be additive but also minor in the short and medium term.

As discussed in Section 3.11.2.8.2, alteration of outflows and a total of 10 drawdowns at seven reservoirs would likely substantially decrease the recreational expenditures within the ROI. Annual deep spring drawdowns in particular at Hills Creek, Cougar, and Green Peter reservoirs would substantially reduce their recreational value during the spring/summer recreation season. RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change would further decrease the recreational quality of visits due to crowding and congestion. The visual effects from the drawdowns and climate change would affect both the quality of the recreational experience as well as the quality of life of nearby residents. Lower recreational quality could lower the amount of revenues expected from each visitor, as well as the probability of repeat visits. Benefits from RFFA 5, federal and state wildlife and lands management; RFFA 7, Tribal, state, and local fish and wildlife improvement; and RFFA 8, invasive species management would also improve the overall quality of fish habitat within the ROI, which could potentially offset some of the adverse effects of climate change on fishery quality and subsequent recreational visitation in the long term. However overall, cumulative, additive effects to recreational value and quality of life would be major and additive in the short and long term (recurring).

As discussed in Section 3.11.2.8.2, alteration of outflows and the drawdowns under Alternative 3B would also significantly reduce the availability of water supply for M&I and agricultural users. The spring drawdowns at Hills Creek, Cougar, and Green Peter in particular would reduce the recharge ability of WVS system-wide and occur during periods of highest use for both agricultural irrigation and M&I purposes. RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change would further reduce water availability. As such, cumulative, additive effects from RFFA 3, RFFA 9, and the ten total drawdowns would be major in the short and long-term (recurring).

As discussed in 3.11.2.4.3, the proposed measures would help preserve the existence value of the UWR Chinook salmon and UWR steelhead and would have long-term, minor, beneficial effects. As discussed above in 4.11.2.3, most of the past, present, and RFFAs would be interactive and countervailing, working against the proposed measures. These would further jeopardize the existence of the ESA-listed fish and therefore overall cumulative, long-term benefits to the existence value of these ESA-listed fish would be negligible.

#### *4.11.3.7 Alternative 4 – Structures-Based Fish Passage Alternative*

Under Alternative 4, the cumulative effects to socioeconomic resources would be similar to those described under Alternative 1. Under this alternative, two additional downstream passage structures would be constructed. Alternative 4 would have the largest expenditures compared to the other alternatives, and therefore would have the greatest beneficial short- and medium-term effects to labor and earnings and most adverse effects to quality of life (and less adverse short and long-term recurring effects to recreational value and M&I use and agricultural irrigation) than Alternatives 2A, 2B, 3A, 3B, and 5.

As described above in 4.11.2.1, the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 10, mining operations; and RFFA 11, timber and logging industry operations would also provide influxes of capital into the ROI and prompt the creation of jobs and a small in-migration of specialized contractors. Construction and maintenance expenditures associated with Alternative 4 would total approximately $2B, which is $200M greater than those of Alternative 1, and the most expensive of the alternatives. As such, cumulative effects to labor and earnings (including low-income populations) would be synergistic, moderate, and beneficial in the short and medium term. Cumulative effects to population and housing would be additive and minor in the short and medium term.

Construction of the structural measures in combination with floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; and the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar would also add noise, emissions, and congestion and therefore have adverse effects to the recreational quality at recreational sites in the vicinity of project activities as well as to the quality of life of nearby residents. The magnitude of effects would depend on the proximity of the cumulative actions and proposed structural measures to the recreational site or the recreationist or the resident, as well as the timing of the projects. For example, if the construction of structural improvements to reduce TDG at Dexter and Cougar occur at the same time as modifications of existing WVS structures at Dexter and Cougar, cumulative effects would be more severe than if they occurred consecutively. As such, cumulative effects to recreational value and quality of life would be moderate and additive in the short and medium term.

As under Alternative 1, the Fall Creek drawdown would also occur annually under Alternative 4. RFFA 1, future population growth and accompanying urban, industrial, and commercial development would further decrease the recreational quality of visits due to crowding and congestion. The visual effects from drawdowns, RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change would affect both the quality of the recreational experience as well as the quality of life of nearby residents (though, there is not a city on the shores of Fall Creek). Lower recreational quality could lower the amount of revenues expected from each visitor, as well as the probability of repeat visits. Benefits from RFFA 5, federal and state wildlife and lands management; RFFA 7, Tribal, state, and local fish and wildlife improvement; and RFFA 8, invasive species management would improve the overall quality of fish habitat within the ROI, which could potentially offset some of the adverse effects of climate change on general fishery quality and subsequent recreational visitation in the long term. But overall, cumulative, additive effects to recreational value and quality of life would be minor and additive in the short and long term (recurring).

As discussed in 3.11.2.6.2, the alteration of outflows and reservoir levels under Alternative 4 would have beneficial, minor effects on water supply in the short and long term. One drawdown during the fall at one location (Fall Creek) would have negligible, short- and long-term recurring adverse effects to water supply. RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change would offset these benefits and have countervailing cumulative effects. As such, overall cumulative effects on M&I use and agricultural irrigation from the proposed measures, RFFA 3, and RFFA 9 would be beneficial and negligible to minor in the short and long term (recurring).

As discussed in 3.11.2.4.3, the proposed measures would help preserve the existence value of the UWR Chinook salmon and UWR steelhead and would have long-term, minor, beneficial effects. As discussed above in 4.11.2.3, most of the past, present, and RFFAs would be interactive and countervailing, working against the proposed measures. These would further jeopardize the existence of the ESA-listed fish and therefore overall cumulative, long-term benefits to the existence value of these ESA-listed fish would be negligible.

#### *4.11.3.8 Alternative 5 – Alternative 5 – Integrated Water Management and ESA-Listed Fish Alternative (using diversion tunnel at CGR)*

Under Alternative 5, the cumulative effects to socioeconomic resources would be identical to those described under Alternative 2B. Alternative 5 differs from Alternative 2B only in its use of a refined integrated temperature and habitat flow regime (#30b).

As described above in 4.11.2.1, the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 10, mining operations; and RFFA 11, timber and logging industry operations would also provide influxes of capital into the ROI and prompt the creation of jobs and a small in-migration of specialized contractors. Cumulative effects to labor and earnings (including low-income populations) would be synergistic, minor, and beneficial in the short and medium term. Cumulative effects to population and housing due to an influx of specialized workers would be additive and minor in the short and medium term.

As described above in 4.11.2.1, construction of the structural measures in combination with floodplain development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; and the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar would also add noise, emissions, and congestion and therefore have adverse effects to the recreational quality as well as to the quality of life of nearby residents. Cumulative effects to recreational value and quality of life would be minor and additive in the short and medium term.

Under Alternative 5, a fall drawdown would occur annually at Fall Creek, Green Peter, and Cougar; a spring drawdown would also occur at Cougar. The spring drawdowns at Cougar would reduce recreational expenditures during the spring/summer recreation season. However, Cougar is one of the least visited reservoirs with the least amount of dollars spent per visit of all 13 reservoirs (USACE 2019e). RFFA 1, future population growth and accompanying urban, industrial, and commercial development would further decrease the recreational quality of visits due to crowding and congestion. The visual effects from drawdowns, RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 10, climate change would affect both the quality of the recreational experience and the quality of life of nearby residents (though, there are no cities directly on the shores of Fall Creek, Green Peter, and Cougar). Benefits from RFFA 5, federal and state wildlife and lands management; RFFA 7, Tribal, state, and local fish and wildlife improvement; and RFFA 8, invasive species management could potentially offset some of the adverse effects of climate change on general fishery quality and subsequent recreational visitation in the long term. Overall, cumulative, additive effects to recreational value and quality of life would still be minor and additive in the short and long term (recurring).

As discussed in 3.11.2.6.2, the alteration of outflows and reservoir levels under Alternative 5 would reduce the availability of water supply for M&I and agricultural users. RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change would further reduce water availability. The spring drawdown in particular at Cougar would reduce the recharge ability of WVS system-wide and occur during periods of highest use for both agricultural irrigation and M&I purposes. As such, cumulative, additive effects from RFFA 3, RFFA 9, and the four total drawdowns would be minor to moderate in the short and long-term (recurring).

As discussed in 3.11.2.4.3, the proposed measures would help preserve the existence value of the UWR Chinook salmon and UWR steelhead and would have long-term, minor, beneficial effects. As discussed above in 4.11.2.3, most of the past, present, and RFFAs would be interactive and countervailing, working against the proposed measures. These would further jeopardize the existence of the ESA-listed fish and therefore overall cumulative, long-term benefits to the existence value of these ESA-listed fish would be negligible.

### 4.11.4 Summary

In summary, Alternatives 1 and 4 would have beneficial effects on labor and earnings than Alternatives 2a, 2b, and 5, which in turn have greater beneficial effects than Alternatives 3a and 3b. Alternatives 3a and 3b have greater adverse effects on the quality of life and recreational value, than Alternatives 1 and 4, which are in turn greater than Alternatives 2a, 2b, and 5. Similarly, Alternatives 3a and 3b would have greater adverse effects to water supply than Alternatives 2a, 2b, and 5, which in turn have greater effects than Alternatives 1 and 4. The cumulative effects on the existence value of ESA-listed fish would be **negligible** and **beneficial** for all alternatives in the **long-term.**

The cumulative effects of Alternative 1 and 4 on labor earnings would be **beneficial,** and **minor** to **moderate** in the **short**, **medium,** and **long term**. Under Alternative 2a, 2b, and 5, the cumulative effects to labor and earnings would be **minor** and **beneficial** in the **short** and **medium term**. The cumulative effects to labor and earnings under Alternative 3a and 3b would be **beneficial,** and **negligible to minor** and in the **short** and **medium term**.

Under Alternatives 1 and 4, there would be **minor** to **moderate, additive, adverse** cumulative effects to recreational value and quality of life in the **short, medium,** and **long term (recurring).** Given the fewer structural measures compared to Alternatives 1 and 4, the cumulative effects of Alternatives 2a, 2b, and 5 on recreational value and the quality of life would be **minor**, **adverse**, and **additive** in the **short, medium,** and **long term (recurring).** Under Alternatives 3a and 3b, the alteration of outflows and a total of 10 drawdowns at seven reservoirs would result in **major** and **additive** cumulative effects to recreational value and quality of life in the **short** and **long term (recurring).**

# 4.12 POWER AND TRANSMISSION

## 4.12.1 Cumulative Effects Analysis Methodology for Power and Transmission

The following sections are a qualitative assessment of anticipated trends and their cumulative impact on power and transmission. This incorporates past, present, and future actions.

### *4.12.1.1 Cumulative Actions Applicable to Power and Transmission*

Past, present, and reasonably foreseeable future actions (RFFAs) that, when considered together with the Proposed Action and alternatives, would have cumulative effects on Power and Transmission include:

- WVS Dams and Reservoirs
- WRB Population Growth and Development
- Near-Term Operations Measure
- Near-Term Structural Measure
- RFFA 1 – Future population growth and accompanying urban, industrial, and commercial development
- RFFA 4 - Decarbonizing the energy sector with renewable energy sources
- RFFA 5 – Vehicle emissions reductions
- RFFA 10 – Climate change

The other RFFAs discussed in Section 4.2.3 do not impact power generation and transmission as they do not impact operations or flow in the river system and do not impact operation of the power system or the energy market as a whole. Therefore, these RFFAs are dismissed from further analysis for Power and Transmission. The near-term operations measure impacts to hydropower generation were analyzed in section 3.13.3.2.8 of Chapter 3.

## 4.12.2 Effects to Power and Transmission by Alternative

Hydropower generation and transmission in the Willamette Valley exists as a result of construction and operation of the WVS dams and reservoirs for flood risk management. Hydropower generation from the WVS dams is integrated into the Federal Columbia River Power System, which is marketed as a system by Bonneville. WVS dams are integrated into the regional transmission system, and provide islanded service to the nearby communities Oakridge and Blue River in weather or fire incidents, as well as during system maintenance. Hydropower generation from the WVS does not specifically supply nearby communities, instead communities served by Bonneville wholesale power receive their power from the entire FCRPS. Specific releases for hydropower generation occur only after operations for other project purposes are optimized, both at the specific reservoir and in coordination among the entire

WVS. Consequently, hydropower generation should be viewed as a residual benefit after other benefits are provided for.

#### *4.12.2.1 No Action Alternative*

Cumulative effects to hydropower and transmission for the No Action Alternative are described for the WVS as a whole.

The cumulative effects of past and present actions including the near-term operations measure, RFFA 10 described above, and the No Action Alternative would be major long-term adverse impacts to power.

Under the No Action Alternative, separate from the near-term operations measure, generation for the Willamette Valley projects would be 171 aMW. This translates to roughly enough to power 136,416 household customers. The loss of load probability (LOLP) refers to the probability that a system demand will exceed capacity during a given period. The LOLP would be 6.5 percent, which is within the current range of the Pacific Northwest Power System recent reliability assessments, but above the five percent standard established by the Northwest Power and Conservation Council. This suggests a risk of blackouts approximately once every fifteen years. The Net Present Value (NPV) for the combined WVS projects would be $225 million. The estimated levelized cost of generation (LCOG)—which refers to the average cost of power generation for a given plant or system—would be $26.70/MWh.

Assuming the near-term operations measures occur under the No Action Alternative, power generation would decrease by 52 aMW, resulting in a NPV of -$196 million, and would increase the LCOG to $38.35/MWh from $26.70/MWh for WVS projects. Note that the near-term operations measure used the No Action Alternative as the baseline, and as such is a direct comparison. There are no costs associated with the near-term operations measure, so these estimated changes would be due solely to a decrease in generation. Costs of near-term structural measures being proposed by the Court-created expert panel are currently unknown but would be expected to reduce the NPV and increase the LCOG.

See Section 3.13 for the full description of the No Action Alternative and the affected environment.

Climate change could further complicate expectations for hydropower generation. While stream flows are expected to increase in the Willamette basin in the winter, which may lead to increased generation, the level of demand is uncertain. There is a potential for a decrease in demand during the time frame analyzed due to increasing temperatures. However, there is also a potential for an increase in Pacific Northwest regional demand during the winter from increased electrification of various sectors (e.g., transportation and use of water/space heaters due to population growth), and load spikes due to temperature fluctuations from extreme weather. See also the climate change section in the Power and Transmission section of Chapter 3.

Overall, cumulative effects on hydropower generation would further impact the expected adverse impacts to the economic viability of power that were described in the "Environmental Consequences" section. Unless energy prices significantly increase at the same time, producing power at Willamette Valley projects—given the other cumulative actions discussed above—would no longer be cost effective.

For Transmission, the cumulative effects of past and present actions including the near-term operations measure, the RFFAs described above, and the No Action Alternative would be long-term moderate impacts. The effect ratings used in this Draft PEIS for power and transmission are based on the unique definitions being used to distinguish among alternatives and are not conclusive for decision making or other studies conducted outside this Draft PEIS.

The creation of the dams and past population growth in the region led to the need to develop the transmission system. Under the No Action Alternative, the Cross Cascades South (CCS) and South of Allston (SOA) transmission paths are congested but operational. Hills Creek and Cougar are capable of islanded operations to provide some isolated communities with power during emergencies such as wildfires.

The near-term operations measure increases loading on the CCS path in both spring (47.0 MW) and winter (59.8 MW). Under the near-term operations measure, Hills Creek would continue to be able to operate islanded, but Cougar may not be able to operate islanded during deep drawdowns.

Population growth and development, decarbonization of the energy sector, and targeted reduction in vehicle emissions could conceivably add loading on the regional transmission system. These potential changes could be quite large, but since the changes to Willamette Valley hydropower generation would be quite small in comparison, the availability of these resources would not significantly impact long-term transmission planning.

The increased potential of extreme weather events and wildfires due to climate change could also affect how frequently transmission lines may temporarily be de-energized. During these events, the diminished ability of Cougar and Hills Creek to operate islanded could affect service to the communities of Blue River and Oakridge.

**Table 4.12-1. Summary of effects for Power and Transmission under No Action Alternative**

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| **Power** | Construction and operation of the WVS Dams and Reservoirs for flood risk management enabled creation of the | The near-term operations measure has a **negligible** impact on power system reliability, blackouts, and LOLP. It would decrease | Same or similar to the affected environment.<br><br>WVS Projects 73-Year average generation is estimated to be 171 aMW for | Climate change may increase or decrease power demand while reducing generation capability during high demand | The cumulative effect of past, present, future actions, as well as the No Action Alternative, would likely be major long- |

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| | Willamette Valley hydropower system. The past WRB Population Growth and Development has contributed to existing regional power demand that is met by the FCRPS. | generation by about 52 aMW and would have long-term major impacts on the economic viability of power generation at the combined WVS projects including a Net Present Value of -$196 million and a levelized cost of generation of $38.35/MWh, which is a decrease of $421M in Net Present Value and increase of $11.65/MWh in the levelized cost of generation over the existing condition.<br><br>Costs of the near-term structural measure are currently unknown but would be expected to reduce the NPV and increase the levelized cost of generation. | the system and the Loss of Load Probability is 6.5%. Under the No Action Alternative, the NPV for the combined WVS projects is estimated to be $225 million and the levelized cost of generation is estimated to be $26.70/MWh. | seasons, especially in the summer. | term adverse impacts to power. |
| **Transmission** | The creation of the WVS Dams and Reservoirs for flood risk management required transmission lines to be built to service the dams. The past WRB | The near-term operations measure would have long-term moderate adverse effects on the transmission system. Deep fall and spring drawdowns | Same or similar to the affected environment. Some transmission lines are currently congested and would remain so. Cougar and Hills Creek | Population growth and development, decarbonization of the energy sector, and targeted reduction in vehicle emissions could conceivably add loading on the regional | The cumulative effect of past, present, future actions, as well as the No Action Alternative, would likely have long-term, moderate |

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| | Population Growth and Development has contributed created demand for transmission in the area. | would compromise the ability of Cougar Dam to operate islanded and serve the community of Blue River under temporary weather or fire related outage conditions.<br><br>The near-term structural measure would not affect transmission. | would remain able to operate islanded and service Blue River and Oakridge communities, respectively, during power system outages due to, especially, weather events or fires. | transmission system.<br><br>The increased potential of extreme weather events and wildfires due to climate change could also affect how frequently transmission lines may temporarily be de-energized. During these events, the diminished ability of Cougar to operate islanded could affect service to the community of Blue River. | adverse impacts on transmission. |

#### *4.12.2.2 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Cumulative effects to hydropower and transmission for Alternative 1 are described for the WVS as a whole.

The cumulative effects of past and present actions—including the near-term operations measure, the RFFAs described above, and Alternative 1—would be major long-term adverse impacts to the economic viability of power generation at Willamette Valley projects. The creation of the system and population growth in the past created the ability to generate power and a demand for that power. The near-term operations measure would decrease power generation by 52 aMW, resulting in a NPV of -$196 million, and would increase the LCOG to $38.35/MWh from $26.70/MWh for Willamette Valley projects. There are no capital costs associated with the near-term operations measure, so these changes are due solely to a decrease in generation.

The direct and indirect impacts on power associated with Alternative 1 would be primarily a result of the costs associated with implementing the alternative as there are positive impacts to generation. Generation at the projects as a whole would increase by 8 aMW under Alternative 1, an increase of 4.7%. The LOLP metric would decrease by 0.1% to 6.4% due to the increase in generation. Due to the costs of the alternative, the NPV for the Willamette Valley would decrease by $1.159 billion to -$934 million. The LCOG would increase by $27.14 to $53.84/MWh. Costs of near-term structural measures are currently unknown but would be expected to further reduce the NPV and increase the LCOG. Note that the near-term operations measure and Alternative 1 were analyzed separately, so metrics associated with each one are not necessarily additive.

See Section 3.13 for the full analysis of direct and indirect effects of Alternative 1 on power.

Climate change further complicates expectations for hydropower generation. While stream flows are expected to increase in the Willamette basin in the winter, which may lead to increased generation, the level of power demand is uncertain. There is a potential for a decrease in demand during the time frame due to increasing temperatures. However, there is also a potential for an increase in Pacific Northwest regional demand during the winter from increased electrification of various sectors (e.g., transportation and water/space heaters), and load spikes due to temperature fluctuations from extreme weather. Decreasing flows and lower reservoir elevations expected in the spring and summer would negatively impact generation going into a high demand summer season, with demand expected to increase as temperatures increase. See also the climate change section in the Power and Transmission section of Chapter 3.

Overall, cumulative effects on hydropower generation would further impact the expected adverse impacts to the economic viability of power that were described in the "Environmental Consequences" section. Unless energy prices significantly increase at the same time, producing power at Willamette Valley projects—given the other cumulative actions discussed above—would no longer be cost effective.

The cumulative effects of past and present actions—including the near-term operations measure, near-term structures measure, RFFA 10 described above, and Alternative 1—would be long-term moderate impacts on the transmission system.

The creation of the dams and past population growth in the region led to the need to develop the transmission system. Currently, the CCS and SOA transmission paths are congested but operational. Hills Creek and Cougar are able to operate islanded to provide Oakridge and Blue River communities, respectively, with power under temporary weather or fire related outage conditions.

The near-term operations measure would increase loading on the CCS path in both spring (47.0 MW) and winter (59.8 MW). Hills Creek would continue to be able to operate islanded, but Cougar may not due to deep drawdowns under the near-term operations measure.

The direct and indirect effects of Alternative 1 would be less than 10MW of increased load on the CCS and SOA paths in all seasons. Hills Creek and Cougar would continue to be able to operate islanded under Alternative 1. However, if the near-term operations measure were implemented in conjunction with Alternative 1, Cougar would have a compromised ability to do so. Note that the near-term operations measure and Alternative 1 were analyzed separately, so metrics associated with each one are not additive and should not be combined.

Population growth and development, decarbonization of the energy sector, and targeted reduction in vehicle emissions could conceivably add loading on the regional transmission system. These potential changes could be quite large, but since the changes to Willamette Valley hydropower generation would be quite small in comparison, the availability of these resources would not significantly impact long-term transmission planning.

The increased potential of extreme weather events and wildfires due to climate change could also affect how frequently transmission lines may temporarily be de-energized. During these events, the diminished ability of Cougar and Hills Creek to operate islanded could affect service to the communities of Blue River and Oakridge.

**Table 4.12-2. Summary of effects for Power and Transmission under Alternative 1 – Improve Fish Passage Through Storage-Focused Measures**

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| Power | The construction and operation of the WRB dams and reservoirs created the Willamette Valley hydropower system. The population growth and the economic development in the region has led to the current demand for power that exists. | The near-term operations measure has a negligible impact on power system reliability, blackouts, and LOLP, but does decrease generation by about 52 aMW. It also would have long-term major impacts on the economic viability of power generation at WVS projects, resulting in a Net Present Value of -$196 and a levelized cost of generation to $38.35/MWh (an increase of $11.65/MWh over the existing condition) for the system. | Alternative 1 would have negligible impacts on power system reliability and long-term major impacts to the economic viability of power generation in the WVS. Average annual generation would increase by 8 aMW and LOLP decreases by 0.1 percent. Alternative 1 would result in a $1.159 billion reduction of NPV to -$934 million and a $27.14 increase in the LCOG to $53.84/MWh. | Climate change may increase or decrease power demand while reducing generation capability during high demand seasons. | Overall, there would be long-term, major, adverse effects on power given cumulative effects of past, present, future actions, and Alternative 1. This alternative would create a situation where power in the Willamette Valley would no longer be cost effective at many of the dams. Other factors unrelated to Alternative 1 itself would have the potential to further adversely impact power. |

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| Transmission | The creation of the WVS Dams and Reservoirs for flood risk management required transmission lines to be built to service the dams. The population growth in the area also created demand for transmission in the area. | The near-term operations measure would have long-term moderate adverse effects on the transmission system. Deep fall and spring drawdowns would also compromise the ability of Cougar Dam to operate islanded and serve the community of Blue River under temporary weather or fire related outage conditions. | Alternative 1 would have long-term, minor adverse effects on the transmission system including some increased loading on already congested transmission paths. | Population growth and development, decarbonization of the energy sector, and targeted reduction in vehicle emissions could conceivably add loading on the regional transmission system.<br><br>The increased potential of extreme weather events and wildfires due to climate change could also affect how frequently transmission lines may temporarily be de-energized. During these events, the diminished ability of Cougar and Hills Creek to operate islanded could affect service to the communities of Blue River and Oakridge. | Overall, there would be long-term, moderate adverse effects on transmission given cumulative effects of past, present, future actions, and Alternative 1. Other factors unrelated to Alternative 1 itself would have the potential to further adversely impact transmission. |

#### *4.12.2.3 Alternative 2a – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Cumulative effects to hydropower and transmission for Alternative 2a are described for the WVS as a whole.

The cumulative effects of past and present actions—including the near-term operations measure, the RFFAs described above, and Alternative 2a—would be major long-term adverse impacts to the economic viability of power generation at Willamette Valley projects. The creation of the system and population growth in the past created the ability to generate power and a demand for that power. The near-term operations measure would decrease power generation by 52 aMW, resulting in a NPV of -$196 million, and would increase the LCOG to $38.35/MWh from $26.70 for Willamette Valley projects. There are no costs associated with the near-term operations measure, so these estimated changes are due solely to a decrease in generation. Costs of near-term structural measures are currently unknown but would be expected to further reduce the NPV and increase the levelized cost of generation.

The direct and indirect impacts on power associated with Alternative 2a would primarily result in the costs associated with implementing the alternative as well as a decrease in generation. Generation at the projects would decrease by 4 aMW under Alternative 2a, a decrease of 2.3%. LOLP would not change from 6.5%. Due to the costs of the alternative, the NPV for the Willamette Valley would decrease by $863 to -$638 million. The LCOG would increase by $20.75 to $47.45/MWh. Note that the near-term operations measure and Alternative 2a were analyzed separately, so metrics associated with each one are not necessarily additive. Changes to hydropower generation resulting from the various cumulative effects would further impact the expected adverse impacts to the economic viability of power that were described in the "Environmental Consequences" section above.

See Section 3.13 for the full analysis of direct and indirect effects of Alternative 2a on power.

Climate change could further complicate expectations for hydropower generation. While stream flows are expected to increase in the Willamette basin in the winter, which may lead to increased generation, the level of demand is uncertain. There is a potential for a decrease in demand during the time frame due to increasing temperatures. However, there is also a potential for an increase in Pacific Northwest regional demand during the winter from increased electrification of various sectors (e.g., transportation and water/space heaters), and load spikes due to temperature fluctuations from extreme weather. See also the climate change section in the Power and Transmission section of Chapter 3.

Overall, cumulative effects on hydropower generation would further impact the expected adverse impacts to the economic viability of power that were described in the "Environmental Consequences" section. Unless energy prices significantly increase at the same time, producing power at Willamette Valley projects—given the other cumulative actions discussed above—would no longer be cost effective.

The cumulative effects of past and present actions including the near-term operations measure, RFFA 10 described above, and Alternative 2a would be long-term moderate impacts on the transmission system. The creation of the dams and past population growth in the region led to the need to develop the transmission system. Currently, the CCS and SOA transmission paths are congested but operational. Hills Creek and Cougar are able to operate islanded to provide Oakridge and Blue River communities, respectively, with power under temporary weather or fire related outage conditions.

The near-term operations measure would increase loading on the CCS path in both spring (47.0 MW) and winter (59.8 MW). Hills Creek would continue to be able to operate islanded, but Cougar may not due to deep drawdowns under the measure.

The direct and indirect effects of Alternative 2a would be increased loading on the CCS path (18.4 MW) in the winter and on both SOA (11.8 MW) and CCS (61.3 MW) in spring.

Hills Creek and Cougar would continue to be able to operate islanded under Alternative 2a. However, if the near-term operations measure were implemented in conjunction with Alternative 2a, Cougar would have a compromised ability to do so. Note that the near-term operations measure and Alternative 2a were analyzed separately, so metrics associated with each one are not additive.

Population growth and development, decarbonization of the energy sector, and targeted reduction in vehicle emissions could conceivably add loading on the regional transmission system. These potential changes could be quite large, but since the changes to Willamette Valley hydropower generation would be quite small in comparison, the availability of these resources would not significantly impact long-term transmission planning.

The increased potential of extreme weather events and wildfires due to climate change could also affect how frequently transmission lines may temporarily be de-energized. During these events, the diminished ability of Cougar and Hills Creek to operate islanded could affect service to the communities of Blue River and Oakridge.

**Table 4.12-3. Summary of effects for Power and Transmission under Alternative 2a – Integrated Water Management Flexibility and ESA-Listed Fish Alternative**

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| Hydropower | The construction and operation of the WRB dams and reservoirs created the Willamette Valley hydropower system. The population growth and the economic development in the region has led to the current demand for | The near-term operations measure has a negligible impact on power system reliability, blackouts, and LOLP, but does decrease generation by about 52 aMW. It also would have long-term major impacts on the economic viability of power generation at WVS projects, resulting in a Net Present Value of - | Alternative 2a would have negligible impacts on power system reliability and long-term major adverse impacts on the economic viability of power generations. Average annual generation decreases by 4 aMW and LOLP remains the same as the No Action | Climate change may increase or decrease power demand while reducing generation capability during high demand seasons. | Overall, there would be long-term, major, adverse effects on power given cumulative effects of past, present, future actions, and Alternative 2a. This alternative would create a situation where hydropower in the Willamette Valley would no longer be cost effective at many of the dams. Other factors |

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| | power that exists. | $196 and a levelized cost of generation to $38.35/MWh (an increase of $11.65/MWh over the existing condition) for the system. | Alternative. Alternative 2a would result in a $863 million reduction of NPV to -$638 million and a $20.75 increase in the LCOG to $47.45/MWh. | | unrelated to Alternative 2a itself would have the potential to further adversely impact hydropower. |
| Transmission | The creation of the dams required transmission lines to be built to service the dams. The population growth in the area also created demand for transmission in the area. | The near-term operations measure would have long-term moderate adverse effects on the transmission system. Deep fall and spring drawdowns would also compromise the ability of Cougar Dam to operate islanded and serve the community of Blue River under temporary weather or fire related outage conditions. | Alternative 2a would have long-term, moderate adverse effects of the transmission system due to increased loading on some of the transmission paths, though Cougar and Hills Creek would remain able to operate islanded. | Population growth and development, decarbonization of the energy sector, and targeted reduction in vehicle emissions could conceivably add loading on the regional transmission system.<br><br>The increased potential of extreme weather events and wildfires due to climate change could also affect how frequently transmission lines may temporarily be de-energized. During these events, the diminished ability of Cougar and Hills Creek to operate islanded could affect service to the communities | Overall, there would be moderate long-term adverse impacts to transmission given cumulative effects of past, present, future actions, and Alternative 2a. Other factors unrelated to Alternative 2a itself would have the potential to further adversely impact transmission. |

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| | | | | of Blue River and Oakridge. | |

### 4.12.2.4 Alternative 2b – Integrated Water Management Flexibility and ESA-Listed Fish Alternative

Cumulative effects to hydropower and transmission for Alternative 2b are described for the WVS as a whole.

The cumulative effects of past and present actions—including the near-term operations measure, the RFFAs described above, and Alternative 2b—would be major long-term adverse impacts to the economic viability of power generation at Willamette Valley projects. The creation of the system and population growth in the past created the ability to generate power and a demand for that power. The near-term operations measure would decrease power generation by 52 aMW, resulting in a NPV of -$196 million, and would increase the LCOG to $38.35/MWh from $26.70/MWh for Willamette Valley projects. There are no costs associated with the near-term operations measure, so these estimated changes are due solely to a decrease in generation. Costs of near-term structural measures are currently unknown but would be expected to further reduce the NPV and increase the levelized cost of generation.

The direct and indirect impacts on power associated with Alternative 2b would be primarily a result of the costs associated with implementing the alternative as well as a decrease in generation. Generation at the projects would decrease by 18 aMW under Alternative 2b, a decrease of 10.5%. LOLP would increase to 6.6%. Due to the costs of the alternative, the NPV for the Willamette Valley would decrease by $933 to -$708 million. The LCOG would increase by $23.96 to $50.66/MWh. Note that the near-term operations measure and Alternative 2b were analyzed separately, so metrics associated with each one are not necessarily additive. Changes to hydropower generation resulting from the various cumulative effects would further impact the expected adverse impacts to the economic viability of power that were described in the "Environmental Consequences" section above.

See Section 3.13 for the full analysis of direct and indirect effects of Alternative 2b on power.

Climate change further complicates expectations. While stream flows are expected to increase in the Willamette basin in the winter, which may lead to increased generation, the level of demand is uncertain. There is a potential for a decrease in demand during the time frame due to increasing temperatures. However, there is also a potential for an increase in Pacific Northwest regional demand during the winter from increased electrification of various sectors (e.g., transportation and water/space heaters), and load spikes due to temperature fluctuations from extreme weather. Decreasing flows and lower reservoir elevations expected in the spring and summer would negatively impact generation going into a high demand summer season, with demand expected to increase as temperatures increase. See also the climate change section in the Power and Transmission section of Chapter 3.

Overall, cumulative effects on hydropower generation would further impact the expected adverse impacts to the economic viability of power that were described in the "Environmental Consequences" section. Unless energy prices significantly increase at the same time, producing power at Willamette Valley projects—given the other cumulative actions discussed above—would no longer be cost effective.

The cumulative effects of past and present actions—including the near-term operations measure, the RFFAs described above, and Alternative 2b—would be long-term moderate impacts on the transmission system. The creation of the dams and past population growth in the region led to the need to develop the transmission system. Currently, the CCS and SOA transmission paths are congested but operational. Hills Creek and Cougar are able to operate islanded to provide Oakridge and Blue River communities, respectively, with power under temporary weather or fire related outage conditions.

The near-term operations measure would increase loading on the CCS path in both spring (47.0 MW) and winter (59.8 MW). Hills Creek would continue to be able to operate islanded, but Cougar may not due to deep drawdowns under the measure.

The direct and indirect effects of Alternative 2b would be increased loading on the CCS path (21.9 MW) in the winter and on both SOA (5.1 MW) and CCS (25.1 MW) in spring.

Hills Creek would continue to be able to operate islanded under Alternative 2b. However, the drawdowns at Cougar under both the near-term operations measure and Alternative 2b would compromise Cougar's ability to operate islanded under temporary weather or fire related outage conditions.

Population growth and development, decarbonization of the energy sector, and targeted reduction in vehicle emissions could conceivably add loading on the regional transmission system. These potential changes could be quite large, but since the changes to Willamette Valley hydropower generation would be quite small in comparison, the availability of these resources would not significantly impact long-term transmission planning.

The increased potential of extreme weather events and wildfires due to climate change could also affect how frequently transmission lines may temporarily be de-energized. During these events, the diminished ability of Cougar and Hills Creek to operate islanded could affect service to the communities of Blue River and Oakridge.

**Table 4.12-4. Summary of effects for Power and Transmission under Alternative 2b – Integrated Water Management Flexibility and ESA-Listed Fish Alternative**

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| Hydropower | The construction and operation of the WRB dams and | The near-term operations measure has a negligible impact on power system | Alternative 2b would have negligible impacts on power system | Climate change may increase or decrease power demand while reducing | Overall, there would be long-term, major, adverse effects on power given |

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| | reservoirs created the Willamette Valley hydropower system. The population growth and the economic development in the region has led to the current demand for power that exists. | reliability, blackouts, and LOLP, but does decrease generation by about 52 aMW. It also would have long-term major impacts on the economic viability of power generation at WVS projects, resulting in a Net Present Value of -$196 and a levelized cost of generation to $38.35/MWh (an increase of $11.65/MWh over the existing condition) for the system. | reliability and long-term major adverse impacts on the economic viability of power generation. Average annual generation would decrease by 18 aMW from the No Action Alternative. Alternative 2b would result in a $933 million reduction of NPV to $708 million and a $23.96 increase in the LCOG to $50.66/MWh | generation capability during high demand seasons. | cumulative effects of past, present, future actions, and Alternative 2b. This alternative would create a situation where hydropower in the Willamette Valley would no longer be cost effective at many of the dams. Other factors unrelated to Alternative 2b itself would have the potential to further adversely impact hydropower. |
| Transmission | The creation of the dams required transmission lines to be built to service the dams. The population growth in the + also created demand for transmission in the area. | The near-term operations measure would have long-term moderate adverse effects on the transmission system. Deep drawdowns would also compromise the ability of Cougar Dam to operate islanded and serve the Blue River community with power under temporary weather or fire related outage conditions. | Alternative 2b would have long-term, moderate adverse effects on the transmission system. There would be increased loading on already congested transmission paths and deep drawdowns at Cougar would make operating islanded difficult under temporary weather or fire | Population growth and development, decarbonization of the energy sector, and targeted reduction in vehicle emissions could conceivably add loading on the regional transmission system.<br><br>The increased potential of extreme weather events and wildfires due to climate change could also affect how frequently transmission lines | The cumulative effects of past, present, future actions, and Alternative 2b on transmission would be moderate, long-term adverse impacts to transmission. The other factors unrelated to Alternative 2b itself would have the potential to further adversely impact transmission. |

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| | | | related outage conditions. | may temporarily be de-energized. During these events, the diminished ability of Cougar and Hills Creek to operate islanded could affect service to the communities of Blue River and Oakridge. | |

#### *4.12.2.5 Alternative 3a – Operations-Focused Fish Passage Alternative*

Cumulative effects to hydropower and transmission for Alternative 3a are described for the WVS as a whole.

The cumulative effects of past and present actions—including the near-term operations measure, the RFFAs described above, and Alternative 3a—would be long-term, moderate adverse impacts to the economic viability of power generation at Willamette Valley projects. The creation of the system and population growth in the past created the ability to generate power and a demand for that power. The near-term operations measure would decrease power generation by 52 aMW, resulting in a NPV of -$196 million, and would increase LCOG to $38.35/MWh from $26.70 for Willamette Valley projects. There are no costs associated with the near-term operations measure, so these estimated changes are due solely to a decrease in generation. Costs of near-term structural measures are currently unknown but would be expected to reduce the NPV and increase the levelized cost of generation.

The direct and indirect impacts on power associated with Alternative 3a would primarily result in the costs associated with implementing the alternative as well as a large decrease in generation. Generation at the projects would decrease by 87 aMW under Alternative 3a, a decrease of 50.9%. LOLP would increase to seven percent. The NPV for the Willamette Valley would decrease by $853 to -$628 million. The LCOG would increase by $37.61 to $64.32/MWh. Note that the near-term operations measure and Alternative 3a were analyzed separately, so metrics associated with each one are not necessarily additive. Changes to hydropower generation resulting from the various cumulative effects would further impact the expected adverse impacts to the economic viability of power that were described in the "Environmental Consequences" section above.

See Section 3.13 for the full analysis of direct and indirect effects of Alternative 3a on power.

Climate change further complicates expectations. While stream flows are expected to increase in the Willamette basin in the winter, which may lead to increased generation, the level of demand is uncertain. There is a potential for a decrease in demand during the time frame due to increasing temperatures. However, there is also a potential for an increase in Pacific Northwest regional demand during the winter from increased electrification of various sectors (e.g., transportation and water/space heaters), and load spikes due to temperature fluctuations from extreme weather. Decreasing flows and lower reservoir elevations expected in the spring and summer would negatively impact generation going into a high demand summer season, with demand expected to increase as temperatures increase. See also the climate change section in the Power and Transmission section of Chapter 3.

Overall, cumulative effects on hydropower generation would further impact the expected adverse impacts to the economic viability of power that were described in the "Environmental Consequences" section. Unless energy prices significantly increase at the same time, producing power at Willamette Valley projects—given the other cumulative actions discussed above—would no longer be cost effective.

The cumulative effects of past and present actions—including the near-term operations measure, RFFAs described above, and Alternative 3a—would be long-term moderate impacts on the transmission system. The creation of the dams and past population growth in the region led to the need to develop the transmission system. Currently, the CCS and SOA transmission paths are congested but operational. Hills Creek and Cougar are able to operate islanded to provide Oakridge and Blue River communities, respectively, with power under temporary weather or fire related outage conditions.

The near-term operations measure would increase loading on the CCS path in both spring (47.0 MW) and winter (59.8 MW). Hills Creek would continue to be able to operate islanded, but Cougar may not due to deep drawdowns under the near-term operations measure.

The direct and indirect effects of Alternative 3a would be increased loading on the CCS (37.2 MW) and SOA (13.6 MW) paths in the winter. It would also lead to increased loading on both paths in spring.

Drawdowns at Hills Creek and Cougar under Alternative 3a would compromise both plants' abilities to operate islanded under temporary weather or fire related outage conditions.

Population growth and development, decarbonization of the energy sector, and targeted reduction in vehicle emissions could conceivably add loading on the regional transmission system. These potential changes could be quite large, but since the changes to Willamette Valley hydropower generation would be quite small in comparison, the availability of these resources would not significantly impact long-term transmission planning.

The increased potential of extreme weather events and wildfires due to climate change could also affect how frequently transmission lines may temporarily be de-energized. During these events, the diminished ability of Cougar and Hills Creek to operate islanded could affect service to the communities of Blue River and Oakridge.

**Table 4.12-5. Summary of effects for Power and Transmission under Alternative 3a – Operations-Focused Fish Passage Alternative**

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| Hydropower | The construction and operation of the WRB dams and reservoirs created the Willamette Valley hydropower system. The population growth and the economic development in the region has led to the current demand for power that exists. | The near-term operations measure has a negligible impact on power system reliability, blackouts, and LOLP, but does decrease generation by about 52 aMW. It also would have long-term major impacts on the economic viability of power generation at WVS projects, resulting in a Net Present Value of -$196 and a levelized cost of generation to $38.35/MWh (an increase of $11.65/MWh over the existing condition) for the system. | Alternative 3a would have negligible impacts on power system reliability and long-term, major effects on the economic viability of power generation. Average annual generation would decrease by 87 aMW and LOLP would increase by 0.5 percent. Alternative 3a would result in a $853 million reduction of NPV to -$628 and a $37.61 increase in the LCOG to 64.32/MWh. | Climate change may increase or decrease power demand while reducing generation capability during high demand seasons. | Overall, there would be long-term, major, adverse effects on power given cumulative effects of past, present, future actions, and Alternative 3a. This alternative would create a situation where hydropower in the Willamette Valley would no longer be cost effective at many of the dams. Other factors unrelated to Alternative 3a itself would have the potential to further adversely impact hydropower. |
| Transmission | The creation of the dams required transmission lines to be built to service the dams. The population growth in the area also created demand for transmission in the area. | The near-term operations measure would have long-term moderate adverse effects on the transmission system. Deep drawdowns would also compromise the ability of Cougar Dam to operate islanded under temporary weather or fire related outage conditions. | Alternative 3a would have long-term, moderate adverse effects on the transmission system. There would be increased loading on existing systems and the ability to operate islanded at Hills Creek and Cougar under | Population growth and development, decarbonization of the energy sector, and targeted reduction in vehicle emissions could conceivably add loading on the regional transmission system.<br><br>The increased potential of | The cumulative effects of past, present, future actions, and Alternative 3a on transmission would be moderate, long-term adverse impacts to transmission. The other factors unrelated to Alternative 3a itself would have the potential to further adversely |

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| | | | temporary weather or fire related outage conditions would be compromised. | extreme weather events and wildfires due to climate change could also affect how frequently transmission lines may temporarily be de-energized. During these events, the diminished ability of Cougar and Hills Creek to operate islanded could affect service to the communities of Blue River and Oakridge. | impact transmission. |

#### *4.12.2.6 Alternative 3b – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)*

Cumulative effects to hydropower and transmission for Alternative 3b are described for the WVS as a whole.

The cumulative effects of past and present actions—including the near-term operations measure, the RFFAs described above, and Alternative 3b—would be major long-term adverse impacts to the economic viability of power generation at Willamette Valley projects. The creation of the system and population growth in the past created the ability to generate power and a demand for that power. The near-term operations measure would decrease power generation by 52 aMW, resulting in a NPV of -$196 million, and would increase the LCOG to $38.35/MWh from $26.70 for Willamette Valley projects. There are no costs associated with the near-term operations measure, so these estimated changes are due solely to a decrease in generation. Costs of near-term structural measures are currently unknown but would be expected to reduce the NPV and increase the levelized cost of generation.

The direct and indirect impacts on power associated with Alternative 3b would be primarily a result of the costs associated with implementing the alternative as well as large decreases in generation. Generation at the projects would decrease by 79 aMW under Alternative 3a, a decrease of 46.2%. LOLP would increase to seven percent. The NPV for the Willamette Valley would decrease by $829 to -$604 million. The LCOG would increase by $32.72 to $59.42/MWh. Note that the near-term operations measure and Alternative 3b were analyzed separately, so metrics associated with each one are not necessarily additive. Changes to hydropower generation resulting from the various cumulative effects would further impact the expected adverse impacts to the economic viability of power that were described in the "Environmental Consequences" section above.

See Section 3.13 for the full analysis of direct and indirect effects of Alternative 3b on power.

Climate change further complicates expectations. While stream flows are expected to increase in the Willamette basin in the winter, which may lead to increased generation, the level of demand is uncertain. There is a potential for a decrease in demand during the time frame due to increasing temperatures. However, there is also a potential for an increase in Pacific Northwest regional demand during the winter from increased electrification of various sectors (e.g., transportation and water/space heaters), and load spikes due to temperature fluctuations from extreme weather. Decreasing flows and lower reservoir elevations expected in the spring and summer would negatively impact generation going into a high demand summer season, with demand expected to increase as temperatures increase. See also the climate change section in the Power and Transmission section of Chapter 3.

Overall, cumulative effects on hydropower generation would further impact the expected adverse impacts to the economic viability of power that were described in the "Environmental Consequences" section. Unless energy prices significantly increase at the same time, producing power at Willamette Valley projects—given the other cumulative actions discussed above—would no longer be cost effective.

The cumulative effects of past and present actions—including the near-term operations measure, the RFFAs described above, and Alternative 3b—would be long-term moderate impacts on the transmission system. The creation of the dams and past population growth in the region led to the need to develop the transmission system. Currently, the CCS and SOA transmission paths are congested but operational. Hills Creek and Cougar are able to operate islanded to provide Oakridge and Blue River communities, respectively, with power under temporary weather or fire related outage conditions.

The near-term operations measure would increase loading on the CCS path in both spring (47.0 MW) and winter (59.8 MW). Hills Creek would continue to be able to operate islanded, but Cougar may not due to deep drawdowns under the measure.

The direct and indirect effects of Alternative 3b would be increased loading on the CCS and SOA paths in all seasons.

Drawdowns at Hills Creek and Cougar under Alternative 3b would compromise both plants' abilities to operate islanded under temporary weather or fire related outage conditions.

Population growth and development, decarbonization of the energy sector, and targeted reduction in vehicle emissions could conceivably add loading on the regional transmission system. These potential changes could be quite large, but since the changes to Willamette

Valley hydropower generation would be quite small in comparison, the availability of these resources would not significantly impact long-term transmission planning.

The increased potential of extreme weather events and wildfires due to climate change could also affect how frequently transmission lines may temporarily be de-energized. During these events, the diminished ability of Cougar and Hills Creek to operate islanded could affect service to the communities of Blue River and Oakridge.

**Table 4.12-6. Summary of effects for Power and Transmission under Alternative 3b – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)**

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| Hydropower | The construction and operation of the WRB dams and reservoirs created the Willamette Valley hydropower system. The population growth and the economic development in the region has led to the current demand for power that exists. | The near-term operations measure has a negligible impact on power system reliability, blackouts, and LOLP, but does decrease generation by about 52 aMW. It also would have long-term major impacts on the economic viability of power generation at WVS projects, resulting in a Net Present Value of -$196 and a levelized cost of generation to $38.35/MWh (an increase of $11.65/MWh over the existing condition) for the system. | Alternative 3b would have negligible impacts on power system reliability and long-term, major effects on the economic viability of power generation. Generation would decrease by 79 aMW and LOLP decreases by 0.5 percent. NPV for the system would be reduced by $829 million to -$604 million. LCOG would increase to $59.42/MWh | Climate change may increase or decrease power demand while reducing generation capability during high demand seasons. | The cumulative effects of past, present, future actions, and Alternative 3b on hydropower would be major, long-term adverse impacts to hydropower. Choosing this alternative creates a situation where hydropower in the Willamette Valley would no longer be cost effective at many of the dams. The other factors unrelated to Alternative 3b itself would have the potential to further adversely impact hydropower. |
| **Transmission** | The creation of the dams required transmission | The near-term operations measure would have long-term | Alternative 3b would have long-term moderate | Population growth and development, decarbonization | The cumulative effects of past, present, future actions, and |

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| | lines to be built to service the dams. The population growth in the area also created demand for transmission in the area. | moderate adverse effects on the transmission system. Deep drawdowns would also compromise the ability of Cougar Dam to operate islanded under temporary weather or fire related outage conditions | adverse effects on the transmission system. This alternative would increase loading on existing transmission systems and compromise the ability of Hills Creek and Cougar to operate islanded under temporary weather or fire related outage conditions. | of the energy sector, and targeted reduction in vehicle emissions could conceivably add loading on the regional transmission system.<br><br>The increased potential of extreme weather events and wildfires due to climate change could also affect how frequently transmission lines may temporarily be de-energized. During these events, the diminished ability of Cougar and Hills Creek to operate islanded could affect service to the communities of Blue River and Oakridge. | Alternative 3b on transmission would be moderate, long-term adverse impacts to transmission. The other factors unrelated to Alternative 3b itself would have the potential to further adversely impact transmission. |

#### *4.12.2.7 Alternative 4 – Structures-Based Fish Passage Alternative*

Cumulative effects to hydropower and transmission for Alternative 4 are described for the WVS as a whole.

The cumulative effects of past and present actions—including the near-term operations measure, the RFFAs described above, and Alternative 4—would be major long-term adverse impacts to the economic viability of power generation at Willamette Valley projects. The creation of the system and population growth in the past created the ability to generate power and a demand for that power. The near-term operations measure would decrease power generation by 52 aMW, resulting in a NPV of -$196 million, and would increase LCOG to $38.35/MWh from $26.70 for Willamette Valley projects. There are no costs associated with the near-term operations measure, so these estimated changes are due solely to a decrease in generation. Costs of near-term structural measures are currently unknown but would be expected to reduce the NPV and increase the levelized cost of generation.

The direct and indirect impacts on power associated with Alternative 4 would be primarily a result of the costs associated with implementing the alternative as there are minor increases in generation. Generation at the projects would increase by 1 aMW under Alternative 4, an increase of 0.6%. LOLP would remain 6.5% under Alternative 4. Again, due to the costs of the alternative, the NPV for the Willamette Valley would decrease by $1.162 billion to -$937 million. The LCOG would increase by $27.84 to $54.54/MWh. Note that the near-term operations measure and Alternative 4 were analyzed separately, so metrics associated with each one are not necessarily additive. Changes to hydropower generation resulting from the various cumulative effects would further impact the expected adverse impacts to the economic viability of power that were described in the “Environmental Consequences” section above.

See Section 3.13 for the full analysis of direct and indirect effects of Alternative 4 on power.

Climate change further complicates expectations for hydropower generation. While stream flows are expected to increase in the Willamette basin in the winter, which may lead to increased generation, the level of demand is uncertain. There is a potential for a decrease in demand during the time frame due to increasing temperatures. However, there is also a potential for an increase in Pacific Northwest regional demand during the winter from increased electrification of various sectors (e.g., transportation and water/space heaters), and load spikes due to temperature fluctuations from extreme weather. Decreasing flows and lower reservoir elevations expected in the spring and summer would negatively impact generation going into a high demand summer season, with demand expected to increase as temperatures increase. See also the climate change section in the Power and Transmission section of Chapter 3.

Overall, cumulative effects on hydropower generation would further impact the expected adverse impacts to the economic viability of power that were described in the “Environmental Consequences” section. Unless energy prices significantly increase at the same time, producing power at Willamette Valley projects—given the other cumulative actions discussed above—would no longer be cost effective.

The cumulative effects of past and present actions—including the near-term operations measure, the RFFAs described above, and Alternative 4—would be long-term minor impacts on the transmission system. The creation of the dams and past population growth in the region led to the need to develop the transmission system. Currently, the CCS and SOA transmission paths are congested but operational. Hills Creek and Cougar are able to operate islanded to provide some isolated communities with power during emergencies such as wildfires.

The near-term operations measure would increase loading on the CCS path in both spring (47.0 MW) and winter (59.8 MW). Hills Creek would continue to be able to operate islanded, but Cougar may not due to deep drawdowns under the measure.

The direct and indirect effects of Alternative 4 would be less than 10MW of increased load on the CCS and SOA paths in all seasons, except an increase of 15MW on the CCS path in spring. Hills Creek and Cougar would continue to be able to operate islanded under Alternative 4. However, if the near-term operations measure were implemented in conjunction with Alternative 4, Cougar would have a compromised ability to do so.

Population growth and development, decarbonization of the energy sector, and targeted reduction in vehicle emissions could conceivably add loading on the regional transmission system. These potential changes could be quite large, but since the changes to Willamette Valley hydropower generation would be quite small in comparison, the availability of these resources would not significantly impact long-term transmission planning.

The increased potential of extreme weather events and wildfires due to climate change could also affect how frequently transmission lines may temporarily be de-energized. During these events, the diminished ability of Cougar and Hills Creek to operate islanded could affect service to the communities of Blue River and Oakridge.

**Table 4.12-7. Summary of effects for Power and Transmission under Alternative 4 – Structures-Based Fish Passage Alternative**

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| Hydropower | The construction and operation of the WRB dams and reservoirs created the Willamette Valley hydropower system. The population growth and the economic development in the region has led to the current demand for power that exists. | The near-term operations measure has a negligible impact on power system reliability, blackouts, and LOLP, but does decrease generation by about 52 aMW. It also would have long-term major impacts on the economic viability of power generation at WVS projects, resulting in a Net Present Value of -$196 and a levelized cost of generation to $38.35/MWh | Alternative 4 would have negligible impacts on power system reliability and long-term adverse effects on the economic viability of power generation. Generation would slightly increase by 1 aMW and LOLP remains the same as the No Action Alternative. However, due to the high cost associated with Alternative 4, the NPV estimate would be reduced by $1.162 billion to | Climate change would likely increase demand for power while reducing generation capability during high demand seasons. | The cumulative effects of past, present, future actions, and Alternative 4 on hydropower would be minor, long-term adverse impacts to hydropower. Choosing this alternative would create a situation where hydropower in the Willamette Valley would no longer be cost effective at many of the dams. The other factors unrelated to Alternative 4 itself would have the potential to further adversely impact hydropower. |

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| | | (an increase of $11.65/MWh over the existing condition) for the system. | -$937 million; and the LCOG would increase by $27.84/MWh to $54.54/MWh. | | |
| Transmission | The creation of the dams required transmission lines to be built to service the dams. The population growth in the area also created demand for transmission in the area. | The near-term operations measure would have long-term moderate adverse effects on the transmission system. Deep drawdowns would also compromise the ability of Cougar Dam to operate islanded in cases of emergency. | Alternative 4 would have long-term, minor effects on the transmission system increased loading on already congested transmission paths. Cougar and Hills Creek would remain able to operate islanded under temporary weather or fire related outage conditions. | Population growth and development, decarbonization of the energy sector, and targeted reduction in vehicle emissions could conceivably add loading on the regional transmission system.<br><br>The increased potential of extreme weather events and wildfires due to climate change could also affect how frequently transmission lines may temporarily be de-energized. During these events, the diminished ability of Cougar and Hills Creek to operate islanded could affect service to the communities of Blue River and Oakridge. | The cumulative effects of past, present, future actions, and Alternative 4 on transmission would be moderate, long-term adverse impacts to transmission. The other factors unrelated to Alternative 4 itself would have the potential to further adversely impact transmission. |

#### *4.12.2.8 Alternative 5 – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Cumulative effects to hydropower and transmission for Alternative 5 are described for the WVS as a whole. It should be noted that these effects were put together using the Alt2b results. The small flow changes under Alt5 as compared to Alt2b could possibly lead to lower generation at Green Peter, Foster, and Hills Creek than is detailed below.

The cumulative effects of past and present actions—including the near-term operations measure, the RFFAs described above, and Alternative 5—would be major long-term adverse impacts to the economic viability of power generation at Willamette Valley projects. The creation of the system and population growth in the past created the ability to generate power and a demand for that power. The near-term operations measure would decrease power generation by 52 aMW, resulting in a NPV of -$196 million, and would increase the LCOG to $38.35/MWh from $26.70/MWh for Willamette Valley projects. There are no costs associated with the near-term operations measure, so these estimated changes are due solely to a decrease in generation. Costs of near-term structural measures are currently unknown but would be expected to further reduce the NPV and increase the levelized cost of generation.

The direct and indirect impacts on power associated with Alternative 5 would be primarily a result of the costs associated with implementing the alternative as well as a decrease in generation. Generation at the projects would decrease by 18 aMW under Alternative 5, a decrease of 10.5%. LOLP would increase to 6.6%. Due to the costs of the alternative, the NPV for the Willamette Valley would decrease by $939 to -$714 million. The LCOG would increase by $24.11 to $50.81/MWh. Note that the near-term operations measure and Alternative 5 were analyzed separately, so metrics associated with each one are not necessarily additive. Changes to hydropower generation resulting from the various cumulative effects would further impact the expected adverse impacts to the economic viability of power that were described in the "Environmental Consequences" section above.

See Section 3.13 for the full analysis of direct and indirect effects of Alternative 5 on power.

Climate change further complicates expectations. While stream flows are expected to increase in the Willamette basin in the winter, which may lead to increased generation, the level of demand is uncertain. There is a potential for a decrease in demand during the time frame due to increasing temperatures. However, there is also a potential for an increase in Pacific Northwest regional demand during the winter from increased electrification of various sectors (e.g., transportation and water/space heaters), and load spikes due to temperature fluctuations from extreme weather. Decreasing flows and lower reservoir elevations expected in the spring and summer would negatively impact generation going into a high demand summer season, with demand expected to increase as temperatures increase. See also the climate change section in the Power and Transmission section of Chapter 3.

Overall, cumulative effects on hydropower generation would further impact the expected adverse impacts to the economic viability of power that were described in the "Environmental Consequences" section. Unless energy prices significantly increase at the same time, producing power at Willamette Valley projects—given the other cumulative actions discussed above—would no longer be cost effective.

The cumulative effects of past and present actions—including the near-term operations measure, the RFFAs described above, and Alternative 5—would be long-term moderate impacts on the transmission system. The creation of the dams and past population growth in the region led to the need to develop the transmission system. Currently, the CCS and SOA transmission paths are congested but operational. Hills Creek and Cougar are able to operate islanded to provide Oakridge and Blue River communities, respectively, with power under temporary weather or fire related outage conditions.

The near-term operations measure would increase loading on the CCS path in both spring (47.0 MW) and winter (59.8 MW). Hills Creek would continue to be able to operate islanded, but Cougar may not due to deep drawdowns under the measure.

The direct and indirect effects of Alternative 5 would be increased loading on the CCS path (21.9 MW) in the winter and on both SOA (5.1 MW) and CCS (25.1 MW) in spring.

Hills Creek would continue to be able to operate islanded under Alternative 5. However, the drawdowns at Cougar under both the near-term operations measure and Alternative 5 would compromise Cougar's ability to operate islanded under temporary weather or fire related outage conditions.

Population growth and development, decarbonization of the energy sector, and targeted reduction in vehicle emissions could conceivably add loading on the regional transmission system. These potential changes could be quite large, but since the changes to Willamette Valley hydropower generation would be quite small in comparison, the availability of these resources would not significantly impact long-term transmission planning.

The increased potential of extreme weather events and wildfires due to climate change could also affect how frequently transmission lines may temporarily be de-energized. During these events, the diminished ability of Cougar and Hills Creek to operate islanded could affect service to the communities of Blue River and Oakridge.

**Table 4.12-8. Summary of effects for Power and Transmission under Alternative 5 – Integrated Water Management Flexibility and ESA-Listed Fish Alternative**

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| **Hydropower** | The construction and operation of the WRB dams and reservoirs created the Willamette Valley hydropower system. The population growth and the economic development in the region has led to the | The near-term operations measure has a negligible impact on power system reliability, blackouts, and LOLP, but does decrease generation by about 52 aMW. It also would have long-term major impacts on the economic viability of power generation at | Alternative 5 would have negligible impacts on power system reliability and long-term major adverse impacts on the economic viability of power generation. Average annual generation would decrease by 18 aMW | Climate change may increase or decrease power demand while reducing generation capability during high demand seasons. | Overall, there would be long-term, major, adverse effects on power given cumulative effects of past, present, future actions, and Alternative 5. This alternative would create a situation where hydropower in the Willamette Valley would no longer be cost effective at many of the |

| Resource | Past Actions | Present Actions | Direct and Indirect Effects | Future Actions | Cumulative Effect |
|---|---|---|---|---|---|
| | current demand for power that exists. | WVS projects, resulting in a Net Present Value of -$196 and a levelized cost of generation to $38.35/MWh (an increase of $11.65/MWh over the existing condition) for the system. | from the No Action Alternative. Alternative 5 would result in a $939 million reduction of NPV to -$714 million and a $24.11 increase in the LCOG to $50.81/MWh | | dams. Other factors unrelated to Alternative 5 itself would have the potential to further adversely impact hydropower. |
| **Transmission** | The creation of the dams required transmission lines to be built to service the dams. The population growth in the + also created demand for transmission in the area. | The near-term operations measure would have long-term moderate adverse effects on the transmission system. Deep drawdowns would also compromise the ability of Cougar Dam to operate islanded and serve the Blue River community with power under temporary weather or fire related outage conditions. | Alternative 5 would have long-term, moderate adverse effects on the transmission system. There would be increased loading on already congested transmission paths and deep drawdowns at Cougar would make operating islanded difficult under temporary weather or fire related outage conditions. | Population growth and development, decarbonization of the energy sector, and targeted reduction in vehicle emissions could conceivably add loading on the regional transmission system.<br><br>The increased potential of extreme weather events and wildfires due to climate change could also affect how frequently transmission lines may temporarily be de-energized. During these events, the diminished ability of Cougar and Hills Creek to operate islanded could affect service to the communities of Blue River and Oakridge. | The cumulative effects of past, present, future actions, and Alternative 5 on transmission would be moderate, long-term adverse impacts to transmission. The other factors unrelated to Alternative 5 itself would have the potential to further adversely impact transmission. |

## 4.13 WATER SUPPLY

### 4.13.1 Cumulative Effects Analysis Methodology for Water Supply

#### *4.13.1.1 Cumulative Actions Applicable to Water Supply*

Past actions, present actions, and RFFAs that, when considered together with the Proposed Action and alternatives, would have cumulative effects on water supply, include:

- WVS Dams and Reservoirs: construction and past operations and maintenance (see section 4.1.2.1.1)
- WRB Population Growth and Development: altered land use within the Willamette River (see section 4.1.2.1.2)
- WVS Dams and Reservoirs: ongoing operations and maintenance (see section 4.1.2.2)
- RFFA 1: Future population growth and accompanying urban, industrial, and commercial development
- RFFA 2: Reduced agricultural development
- RFFA 3: Water withdrawals for municipal, industrial, and agricultural uses
- RFFA 5: Federal and state wildlife and lands management
- RFFA 7: Tribal, state, and local fish and wildlife improvement
- RFFA 9: Climate change

Some of the other RFFAs discussed in Section 4.2.3 would not change the hydrology of the Willamette Basin or only negligibly alter the WVS dam and reservoir operations and as such would not have a cumulative effect on Water Supply.

- RFFA 4: Decarbonizing the energy sector with renewable energy sources. There is minimal variation in total flow due to outlet choice, such as whether to run the WVS dam's hydroelectric turbines.
- RFFA 6: Fishery management and killer whales. The flow targets in the WVS are specific to the river reaches and habitat where they occur. They are not variable based on Pacific Ocean salmon returns.
- RFFA 8: Invasive species management. Does not affect flow or regulation decisions for the WVS dams.
- RFFA 10: Mining operations. Negligible cumulative changes to total flow in the Willamette Basin from the status quo.
- RFFA 11: Timber and logging industry operations. Negligible cumulative changes to total flow in the Willamette Basin from the status quo.

Therefore, these RFFAs are dismissed from further analysis.

### 4.13.2 Cumulative Effects Analysis Methodology for Water Supply

Table 4.13-1 below describes the cumulative effect from the applicable RFFAs noted above.

**Table 4.13-1. Reasonable and Foreseeable Future Actions applicable to water supply.**

| RFFA # | RFFA Description | Cumulative Effect Description |
|---|---|---|
| RFFA 1 | Future population growth and urban, industrial, and commercial development | Increased water demand basin wide, resulting in decreased water in the streams. |
| RFFA 2 | Future agricultural development | Conversion of cropland to urban development, resulting in decreased demand for irrigation water and an increased demand for M&I water supply. |
| RFFA 3 | Water withdrawals for municipal, industrial, and agricultural uses | An increase in water withdrawals may result in decreased streamflows. |
| RFFA 5 | Federal and State Wildlife and Lands Management | Potential increased demand for M&I water supply. |
| RFFA 7 | Tribal, State, and local fish and wildlife improvement | Potential adverse effect to water supply as instream flows are protected with senior instream water rights. |
| RFFA 9 | Climate Change | A decrease in flow and water volumes in the summer may have an adverse effect on water supply as users aren’t able to withdraw water from the stream for consumptive uses. |

As noted in Sections 4.1.2.1.1 and Section 4.3.3. (hydrologic processes), the WVS dams have altered the hydrology in the mainstem Willamette River and in some of the tributaries in the WRB, most notably affecting water supply in the summer months when naturally low flows are augmented by releases of stored water from the federal dams. Low flow augmentation allows existing water right holders to withdraw water from the streams for longer period of times and in many years when natural streamflows would not be available to satisfy all water rights issued by the state.

Past WRB population growth in the WVS watershed noted in Section 4.1.2.1.2 has resulted in increased withdrawals from the rivers and streams to supply demands for both municipal and industrial water supply needs. While cropland has decreased basin wide, there is an increasing need for irrigation water supply to increase productivity on existing agricultural lands. These increased withdrawals increase the need and benefit of stored water releases from the reservoirs to support instream purposes.

Future population growth and accompanying urban, industrial, and commercial development (RFFA 1) is likely to lead to increased water withdrawals for municipal, industrial (M&I), and agricultural uses (RFFA 3). Increased demands for M&I and agricultural uses were the driving force behind the Willamette Basin Review reallocation feasibility study completed in 2019, resulting in reallocation of conservation storage space in the WVS reservoirs. These two RFFAs were considered in the Water Supply analyses in Chapter 3.

As noted in Hydrologic Processes Section 4.3.3 above, future federal and state lands management (RFFA 5) is not likely to result in noticeable differences to inflow to the reservoirs nor alter the volume of flow in the rivers downstream of the dams. Land management actions could result in increased urbanization, thus resulting in need for additional municipal and industrial water supply. This need has been forecasted in and included in the Water Supply Environmental Consequences for the No Action and Action Alternative in Chapter 3.

Tribal, state, and local fish and wildlife improvement (RFFA 7) could result in conversion of the minimum perennial streamflows (MPSFs) to instream water rights, giving instream flows protection and seniority against out of stream uses. This could result in existing users needing alternative sources of water supply, for both M&I and agricultural irrigation. This was considered as part of the Willamette Basin Review (WBR) feasibility study resulting in reallocation of the conservation storage to the authorized purposes of M&I water supply, irrigation, and fish and wildlife. Effects of this increased demand were included in the Water Supply analyses in Chapter 3.

Climate change (RFFA 9) is likely to increase the demand for M&I water supply and agricultural irrigation. These effects were considered during the WBR forecasting for future demands of stored water and included in the reallocation volumes for M&I water supply and irrigation. These effects were also addressed in the Water Supply section of Chapter 3.

### 4.13.3 Cumulative Effects to Water Supply by Alternative

The effects of the RFFAs, including climate change, were included in the Water Supply Environmental Consequences section of Chapter 3. No additional effects are expected in addition to those described in Chapter 3.

## 4.14 RECREATION

This section discusses the cumulative effects on recreation. This includes a discussion of the effects of proposed measures considered alongside applicable cumulative actions, and how each alternative would cumulatively affect recreation. The geographic scope for recreation would be the same boundary as described in the Affected Environment in Chapter 3, which is the boundary of the WRB. This includes the 13 Oregon counties that intersect or lie within the boundary: Benton, Clackamas, Columbia, Douglas, Klamath, Lane, Linn, Marion, Multnomah, Polk, Tillamook, Washington, and Yamhill counties.

### 4.14.1 Cumulative Actions Applicable to Recreation

Past, present, and reasonably foreseeable future actions that, when considered together with the Proposed Action and alternatives, would have cumulative effects on recreation, include:

- Construction of the WVS dams, non-USACE dams, and supporting structures;
- Modifications of existing WVS structures at Dexter, Big Cliff, and Cougar;
- WRB population growth and development;
- Transportation corridor development;
- Point and non-point source water pollution;
- RFFA 1, future population growth and accompanying urban, industrial, and commercial development;
- RFFA 3, water withdrawals for municipal, industrial, and agricultural uses;
- RFFA 5, federal and state wildlife and lands management;
- RFFA 6, fishery management and killer whales;
- RFFA 7, tribal, state, and local fish and wildlife improvement;
- RFFA 8, invasive species management;
- RFFA 9, climate change; and
- RFFA 10, mining operations.

Some of the RFFAs discussed above in Section 4.2.3 would not have effects on recreation. These include RFFA 2, reduced agricultural production; RFFA 4, decarbonizing the energy sector with renewable energy sources; and RFFA 11, timber and logging industry operations. No new logging operations have been proposed in the WRB. If new logging operations began in the future, it is unlikely that operations would occur near the shores of any WVS reservoirs due to local zoning ordinances. Therefore, these RFFAs are not discussed further in this cumulative effects analysis.

### 4.14.2 Discussion of Cumulative Effects by Measure(s)

This section considers the proposed measures with applicable cumulative actions to determine the potential cumulative effect to recreation. Where possible, the discussion of cumulative effects is grouped by measures that would have similar effects.

#### *4.14.2.1 Gravel augmentation below dams (#384), Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), Maintenance of existing and new fish release sites above dams (#726), Restore upstream and downstream passage at drop structures (#639), Use spillway for surface spill in summer (#721), Provide Pacific lamprey passage and infrastructure (#52), Operation, Maintenance, Repair, Replacement and Rehabilitation, Structural improvements to reduce total dissolved gas (#174), Construct WTC towers (#105), Construct structural downstream fish passage (#392), Foster Fish Ladder Temperature Improvement (#479), and Construct AFF (#722)*

As discussed in Sections 3.14.2.4.1 through 3.14.2.4.3 and Section 3.14.2.4.7, adverse effects from construction activities associated with these measures would range from negligible to moderate in magnitude and occur in the short and medium term. Modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; and RFFA 1, future population growth and accompanying urban, industrial, and commercial development would have similar effects as construction from the proposed measures. RFFA 9, climate change and RFFA 10, mining operations would have effects similar to those of construction from the proposed measures, but would occur in the short, medium, and long term. These cumulative actions would also affect the recreational experience due to noise and air emissions, traffic from hauling material, and from generally attracting attention due to changes in the viewshed. RFFA 9, climate change (discussed in greater detail below in Section 4.14.2.3), would further exacerbate the decreased recreational experience from water pollution due to lower water levels and higher water temperatures, increasing the likelihood of HABs that could further adversely affect water quality. The quality of recreational fishing along rivers for some species could be further adversely impacted in the short, medium, and long term due to the increased turbidity from suspended sediment and other potential pollution. As with direct effects to the recreational experience discussed in Section 3.14, the magnitude of the short- and medium-term construction-related effects from the cumulative actions on the quality of recreation depends on the proximity of the construction project site to the recreational facility or the recreator.

Modifications of existing WVS structures would include upgrades to the existing Dexter AFF, a structural solution for mitigating excess TDG levels during spill operations at Big Cliff, and a structural solution to improve and/or modify Cougar Dam's ROs to ensure safer fish passage and reduced TDG levels. The type, location, and size of these cumulative actions are very similar to measures proposed in the action alternatives. RFFA 1, future population growth and accompanying urban, industrial, and commercial development would continue to occur along the I-5 corridor (closest to the cities of Corvallis, Eugene, and Portland). Effects on recreational quality would occur along the mainstem Willamette River and at any recreational facility or to any recreator near construction and development; the severity of the effect would dependent on the proximity of the recreator or the recreational facility. However, as discussed in Section 3.15.2, far less development will occur in the future than has already occurred in the past. Adverse effects on recreation from intense development are less likely to occur at WVS reservoirs due to local zoning ordinances that may prohibit commercial or industrial development near shorelines – except for residential development at Detroit, Dexter, Fern Ridge, and Foster reservoirs, which have the towns of Detroit, Lowell, Veneta, and Sweet Home on their shores, respectively.

Like the RFFAs discussed above, RFFA 10, mining operations would also affect the recreational experience due to noise and air emissions, traffic from hauling material, and from generally attracting attention due to changes in the viewshed. Mining could also contribute to water pollution, such as increased turbidity from suspended sediment, discharged mine effluent, and seepage from tailings and waste rock impoundments, which would further decrease the quality of the recreational experience. Although no new mine sites have been proposed in the WRB, many existing claims exist, and there are several claims adjacent to WVS reservoirs. If new mining operations began in the future, these operations would continue in the long term, but it is unlikely that intensive or large-scale operations would occur near the shores of any WVS reservoirs due to local zoning ordinances. Further, mining operations would be required to comply with environmental regulations (as applicable), such as Section 402 of the Clean Water Act, which would mitigate effects of water pollution and ensure adequate water quality for enjoyable recreational experiences.

Overall short-, medium-, and long-term, cumulative effects on the recreational experience of the proposed structural measures in combination with transportation and residential development, potential mining operations, climate change, and the construction or modification of WVS structures would be negligible to moderate, additive, and adverse. In the long term, the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar (specifically) in combination with the proposed measures (except for providing Pacific lamprey passage and infrastructure because Pacific lamprey are not fished recreationally and Operation, Maintenance, Repair, Replacement and Rehabilitation because the purpose of this measure is not specifically to benefit ESA-listed fish) would have beneficial, minor, additive, cumulative effects on recreational fishing.

#### 4.14.2.2 *Integrated temperature and habitat flow regime (#30a), Refined integrated temperature and habitat flow regime (#30b), Use regulating outlets to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166), Augment instream flows by using the inactive pool (#718), Augment instream flows by using the power pool (#304), Pass water over spillway in spring for fish passage (#714), Continued Operation of Existing AFFs, and Reduce minimum flows to Congressionally authorized minimum flow requirements (#723)*

As discussed in Section 3.14.2.4.4, the effects of these measures (except #723) would be indirect, beneficial, and minor in the long term. As discussed in Section 3.14.2.4.5, the effects of reducing minimum flows to Congressionally authorized minimum flow requirements (#723) would be moderate and beneficial at reservoirs in the long term. The results of RFFAs 6, 7, and 8 would have similar effects on recreation as the measures listed above.

RFFA 6, fishery management and killer whales would improve the management of salmon fisheries in offshore ocean waters. Although the Pacific Ocean is outside of the boundary of the WRB, salmon are anadromous, and this RFFA could eventually benefit salmon and recreational fishing in the WVS. RFFA 7, tribal, state, and local fish and wildlife improvement generally promotes habitat and ecosystem functions, as well as species-specific conservation. One recent project restored a stretch of the Willamette River and provided resting spots for salmon, wetland habitat for wildlife, and fertile floodplains for trees, shrubs, and other plants. RFFA 8, invasive species management would prevent and eradicate invasive bass that disrupt aquatic ecosystems by preying on native fish, which would improve recreational fishing. Both land- and water-based recreational experiences would benefit from improved fishery and invasive species management, fish and wildlife habitat, and riparian aesthetics in general. Therefore, when considered in tandem with RFFAs 6, 7, and 8, the proposed measures would result in indirect, beneficial, additive, and minor cumulative effects to recreational fishing and the recreational experience in the long term.

#### 4.14.2.3 *Deeper fall reservoir drawdowns for fish passage (#40), Spring reservoir drawdown for downstream fish passage (#720), Fall Creek drawdown, and Suite of near-term operations*

As discussed in Section 3.14.2.4.8, the effects of reservoir drawdowns and the suite of near-term operations would be major, adverse, short-term and recur in the long term. Visitation would decrease during drawdowns; and some recreationists would continue to visit the reservoir despite drastic changes in the WSE. Drawdowns would substantially impact the recreational experience for those who continue to visit the reservoir during this time. RFFA 3, water withdrawals for municipal, industrial, and agricultural uses, and RFFA 9, climate change, would also affect both the recreational experience and opportunities.

RFFA 3, water withdrawals for municipal, industrial, and agricultural uses, is expected to decrease the amount of water flowing through the WVS due to increasing water demands. Decreased flows would be further exacerbated by RFFA 9, climate change. Climate change is expected to result in less snowpack, drier, hotter summers (in terms of both air and water temperatures), and increased evaporation. Both would limit the quantity of water available in the WVS for recreation, which could shorten the recreational season.

As water quantity decreases in the future, water quality and air quality could also decrease due to RFFA 9, climate change; and affect both the recreational experience as well as opportunities. Higher air and water temperatures, less water in river and reservoir systems, and more frequent and severe wildfires would decrease water quality from higher turbidity, elevated concentrations of contaminants such as mercury and wildfire ash, and increased occurrence of HABs which could affect the recreational experience. Increased occurrence and severity of wildfires would substantially degrade air quality during wildfire season, which would not only decrease the quality of the recreational experience due to adverse visual impacts, but could put recreationists at risk of health effects due mainly to particle pollution, a main component of wildfire smoke. During times when regional air quality from wildfire smoke is poor, the majority of recreationists are likely to forego outdoor recreation; recreational areas or part or all of the reservoir(s) may be closed.

While the effects of water withdrawals and climate change may only be slightly noticeable on the quantity and quality of recreation available, these effects would become more adverse over time as water levels fall and temperatures climb higher. When considered in tandem with RFFA 3 and RFFA 9, reservoir drawdowns and delayed refills would create adverse, additive, and major cumulative effects on the recreational experience and opportunities in both the short and long term (recurring).

RFFA 5, federal and state wildlife and lands management, involves designating and managing lands such as wildlife refuges and national forests. The recent revision to the Oregon Statewide Planning Goals and Guidelines included a goal to establish a Willamette greenway, which would provide additional recreational opportunities for bike riding, walking, and viewing wildlife. Because visitation to reservoirs would decrease during drawdowns, the provision of additional recreational opportunities from the Willamette greenway would have interactive, countervailing cumulative effects on recreation. However overall, the proposed drawdowns in combination with the Willamette greenway would still have major, adverse, cumulative effects on recreational opportunities.

A study of the effects of the Fall Creek drawdown has shown that it reduced abundance of warm-water invasive fishes in the reservoir after it refills, in addition to improving passage and connectivity for juvenile Chinook salmon (Murphy et al. 2019). Drawdowns have also been used for invasive plant control, which can benefit fisheries; but can also increase water column nutrient concentrations and temperature of shallow water layers and lead to algal blooms (MWRA 2021; Cooke 1980; Bakker and Hilt 2016). RFFA 8, invasive species management would prevent and eradicate invasive bass that disrupt aquatic ecosystems by preying on native fish, which would improve recreational fishing. Therefore, when considered together with RFFA 8, drawdowns would result in indirect, beneficial, additive, and minor cumulative effects to recreational fishing and the recreational experience in the long term.

### 4.14.3 Discussion of Cumulative Effects by Alternative

This section analyzes the relevant cumulative actions by alternative to determine the potential cumulative effects to recreation.

### 4.14.4 No Action Alternative

Under the NAA, the existing O&M of the WVS would continue. The NAA includes water quality, flow, and upstream and downstream fish passage operations, which includes an annual drawdown at the Fall Creek Reservoir. Operation, maintenance, repair, replacement, and rehabilitation under the NAA would continue to adversely impact the recreational experience. Effects to the recreational experience would be would be adverse and range from negligible to moderate in the short, medium, and long term for scheduled/routine maintenance and major maintenance and rehabilitation due to increases in noise, air emissions, visual intrusions, and traffic. As discussed above in Section 4.14.2.1, modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 9, climate change; and RFFA 10, mining operations in combination with the operation, maintenance, repair, replacement, and rehabilitation under the NAA would have negligible to moderate short, medium and long term (recurring) additive cumulative effects. The severity of effects would increase proportionally with the recreational facility's or recreator's proximity to these activities.

As discussed above in Section 4.14.2.3, when considered in tandem with RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change, the recurring Fall Creek Drawdown would create adverse, additive, and major cumulative effects to recreational experiences and opportunities in the short and long term (recurring). Because visitation to reservoirs would decrease during drawdowns, the provision of additional recreational opportunities from RFFA 5, federal and state wildlife and lands management would have interactive, countervailing cumulative effects on recreation. However overall, the proposed drawdowns in combination with the Willamette greenway would still have major, adverse, cumulative effects on recreational opportunities in the short and long term (recurring).

As discussed above in 4.14.2.3, drawdowns at other reservoirs have been used to control invasive plants, which can also benefit fisheries (MWRA 2021; Cooke 1980). At Fall Creek in particular, the drawdown has shown to reduce the abundance of warm-water invasive fishes in the reservoir after it refills, in addition to improving passage and connectivity for juvenile Chinook salmon (Murphy et al 2019). When considered together with RFFA 8, invasive species management, the Fall Creek Drawdown would result in indirect, beneficial, additive, and minor cumulative effects to recreational fishing and the recreational experience in the long term.

### 4.14.5 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures

Alternative 1 would combine storage-focused measures in order to improve fish passage. Augmenting gravel below dams (#384); maintaining or altering revetments (#9); maintaining existing and new fish release sites (#726); restoring upstream and downstream passage at drop structures (#639); providing Pacific lamprey passage and infrastructure (#52); operation, maintenance, repair, replacement and rehabilitation; improving structures to reduce total dissolved gas (#174); constructing WTC Towers (#105), AFFs (#722), and structural downstream fish passage (#392); and the Foster Fish Ladder Temperature Improvement (#479) would have negligible to moderate adverse effects on the recreational experience in the short and medium term due to increases in noise, air emissions, visual intrusions, and traffic. In the long term, recreational fishing could benefit indirectly. Modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 9, climate change; and RFFA 10, mining operations in combination with the above-listed structural measures under Alternative 1 would have negligible to moderate cumulative and additive effects on the recreational experience in the short, medium, and long term. In the long term, the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar (specifically) in combination with the proposed measures (except for providing Pacific lamprey passage and infrastructure and Operation, Maintenance, Repair, Replacement and Rehabilitation) would have beneficial, minor, additive, cumulative effects on recreational fishing.

Augmenting instream flows by using the inactive pool and augmenting instream flows by using the power pool would have indirect, beneficial, and minor effects in the long term. These measures in combination with RFFA 6, fishery management and killer whales, RFFA 7, tribal, state, and local fish and wildlife improvement, and RFFA 8, invasive species management would have minor, beneficial, additive, cumulative effects in the long term due to vegetation and habitat improvement projects and improved reservoir storage.

As discussed above in Section 4.14.2.3, when considered in tandem with RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change, the recurring Fall Creek Drawdown would create adverse, additive, and major cumulative effects to recreational experiences and opportunities. Because visitation to reservoirs would decrease during drawdowns, the provision of additional recreational opportunities from RFFA 5, federal and state wildlife and lands management would have interactive, countervailing cumulative effects on recreation. Alternative 1 is also the only action alternative that would result in direct benefits to recreation by promoting reservoir storage and therefore would also have interactive, countervailing cumulative effects on increased water demand and climate change and the associated effects to recreation. However, despite reducing minimum flows to the Congressionally authorized minimum flow requirements and the addition of the Willamette greenway, the proposed drawdowns would still have major, adverse, additive, cumulative effects on recreational opportunities in the short and long term (recurring).

As discussed above in 4.14.2.3, drawdowns at other reservoirs have been used to control invasive plants, which can also benefit fisheries (MWRA 2021; Cooke 1980). At Fall Creek in particular, the drawdown has shown to reduce the abundance of warm-water invasive fishes in the reservoir after it refills, in addition to improving passage and connectivity for juvenile Chinook salmon (Murphy et al 2019). When considered together with RFFA 8, invasive species management, the Fall Creek Drawdown would result in indirect, beneficial, additive, and minor cumulative effects to recreational fishing and the recreational experience in the long term.

Under Alternative 1, adverse cumulative effects would be less severe than all other action alternatives. Alternative 1 includes only one recurring drawdown at Fall Creek and does not include the suite of near-term operations.

### 4.14.6 Alternative 2a – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam)

Alternative 2a would integrate water management flexibility and ESA-listed fish measures (using structural downstream passage at Cougar Dam). Augmenting gravel below dams (#384); maintaining or altering revetments (#9); maintaining existing and new fish release sites (#726); providing Pacific lamprey passage and infrastructure (#52); operation, maintenance, repair, replacement, and rehabilitation; constructing WTC Towers (#105), AFFs (#722), and structural downstream fish passage (#392); and the Foster Fish Ladder Temperature Improvement (#479) would have negligible to moderate adverse effects on the recreational experience in the short and medium term due to increases in noise, air emissions, visual intrusions, and traffic. In the long term, recreational fishing could benefit indirectly. Modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 9, climate change; and RFFA 10, mining operations in combination with the above-listed structural measures under Alternative 2a would have negligible to moderate cumulative and additive effects on the recreational experience in the short, medium, and long term. In the long term, the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar (specifically) in combination with the proposed measures (except for providing Pacific lamprey passage and infrastructure and Operation, Maintenance, Repair, Replacement and Rehabilitation) would have beneficial, minor, additive, cumulative effects on recreational fishing.

Augmenting instream flows by using the inactive pool, augmenting instream flows by using the power pool, and the integrated habitat and flow regime would have indirect, beneficial, and minor effects in the long term. These measures in combination with RFFA 6, fishery management and killer whales, RFFA 7, tribal, state, and local fish and wildlife improvement, and RFFA 8, invasive species management would have minor, beneficial, additive, cumulative effects in the long term due to vegetation and habitat improvement projects.

As discussed above in Section 4.14.2.3, when considered in tandem with RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change, the drawdowns at Fall Creek and Green Peter and the suite of near-term operations would create adverse, additive, and major cumulative effects to recreational experiences and opportunities. Because visitation to reservoirs would decrease during drawdowns, the provision of additional recreational opportunities from RFFA 5, federal and state wildlife and lands management would have interactive, countervailing cumulative effects on recreation.

As discussed above in 4.14.2.3, drawdowns at other reservoirs have been used to control invasive plants, which can also benefit fisheries (MWRA 2021; Cooke 1980). At Fall Creek in particular, the drawdown has shown to reduce the abundance of warm-water invasive fishes in the reservoir after it refills, in addition to improving passage and connectivity for juvenile Chinook salmon (Murphy et al 2019). When considered together with RFFA 8, invasive species management, the drawdowns at Fall Creek and Green Peter would result in indirect, beneficial, additive, and minor cumulative effects to recreational fishing and the recreational experience in the long term.

Under Alternative 2a, adverse cumulative effects would be more severe than Alternative 1 but less severe than Alternatives 2b, 3a, 3b, 4, and 5.

### 4.14.7 Alternative 2b – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)

Alternative 2b would integrate water management flexibility and ESA-listed fish measures (using a deep drawdown to Cougar Dam’s DT). Augmenting gravel below dams (#384); maintaining or altering revetments (#9); maintaining existing and new fish release sites (#726); providing Pacific lamprey passage and infrastructure (#52); operation, maintenance, repair, replacement, and rehabilitation; constructing WTC Towers (#105), AFFs (#722), and structural downstream fish passage (#392); and the Foster Fish Ladder Temperature Improvement (#479) would have negligible to moderate adverse effects on the recreational experience in the short and medium term due to increases in noise, air emissions, visual intrusions, and traffic. In the long term, recreational fishing could benefit indirectly. Modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; and RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 9, climate change; and RFFA 10, mining operations in combination with the above-listed structural measures under Alternative 2b would have negligible to moderate cumulative and additive effects on the recreational experience in the short, medium, and long term. In the long term, the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar (specifically) in combination with the proposed measures (except for providing Pacific lamprey passage and infrastructure and Operation, Maintenance, Repair, Replacement and Rehabilitation) would have beneficial, minor, additive, cumulative effects on recreational fishing.

Augmenting instream flows by using the inactive pool and the power pool and the integrated habitat and flow regime would have indirect, beneficial, and minor effects in the long term. These measures in combination with RFFA 6, fishery management and killer whales, RFFA 7, tribal, state, and local fish and wildlife improvement, and RFFA 8, invasive species management would have minor, beneficial, additive, cumulative effects in the long term due to vegetation and habitat improvement projects.

As discussed above in Section 4.14.2.3, when considered in tandem with RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change, the drawdowns at Cougar, Fall Creek, and Green Peter and the suite of near-term operations would create adverse, additive, and major cumulative effects to recreational experiences and opportunities. Because visitation to reservoirs would decrease during drawdowns, the provision of additional recreational opportunities from RFFA 5, federal and state wildlife and lands management would have interactive, countervailing cumulative effects on recreation.

As discussed above in 4.14.2.3, drawdowns at other reservoirs have been used to control invasive plants, which can also benefit fisheries (MWRA 2021; Cooke 1980). At Fall Creek in particular, the drawdown has shown to reduce the abundance of warm-water invasive fishes in the reservoir after it refills, in addition to improving passage and connectivity for juvenile Chinook salmon (Murphy et al 2019). When considered together with RFFA 8, invasive species management, the drawdowns at Cougar, Fall Creek, and Green Peter would result in indirect, beneficial, additive, and minor cumulative effects to recreational fishing and the recreational experience in the long term.

Under Alternative 2b, adverse cumulative effects would be the same in severity as Alternative 5, more severe than Alternatives 1 and 2a, but less severe than Alternatives 3a, 3b, or 4.

### 4.14.8 Alternative 3a – Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)

Alternative 3a would improve fish passage by using operations-focused measures (using a deep drawdown to Cougars Dam’s RO). Augmenting gravel below dams (#384), maintaining or altering revetments (#9), maintaining existing and new fish release sites (#726), providing Pacific lamprey passage and infrastructure (#52), operation, maintenance, repair, replacement, and rehabilitation; and constructing AFFs (#722) would have negligible to moderate adverse effects on the recreational experience in the short and medium term due to increases in noise, air emissions, visual intrusions, and traffic. In the long term, recreational fishing could benefit indirectly. Modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 9, climate change; and RFFA 10, mining operations in combination with the above-listed structural measures under Alternative 3a would have negligible to moderate cumulative and additive effects on the recreational experience in the short, medium, and long term. In the long term, the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar (specifically) in combination with the proposed measures (except for providing Pacific lamprey passage and infrastructure and Operation, Maintenance, Repair, Replacement and Rehabilitation) would have beneficial, minor, additive, cumulative effects on recreational fishing.

Using the spillway for surface spill, augmenting instream flows by using the inactive and power pools, and integrated habitat and flow regime would have indirect, beneficial, and minor effects in the long term. These measures in combination with RFFA 6, fishery management and killer whales, RFFA 7, tribal, state, and local fish and wildlife improvement, and RFFA 8, invasive species management would have minor, beneficial, additive, cumulative effects in the long term due to vegetation and habitat improvement projects.

As discussed above in Section 4.14.2.3, when considered in tandem with RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change, the ten drawdowns across seven reservoirs as well as the suite of near-term operations under Alternative 3a would create adverse, additive, and major cumulative effects to recreational experiences and opportunities. Because visitation to reservoirs would decrease during drawdowns, the provision of additional recreational opportunities from RFFA 5, federal and state wildlife and lands management would have interactive, countervailing cumulative effects on recreation.

As discussed above in 4.14.2.3, drawdowns at other reservoirs have been used to control invasive plants, which can also benefit fisheries (MWRA 2021; Cooke 1980). At Fall Creek in particular, the drawdown has shown to reduce the abundance of warm-water invasive fishes in the reservoir after it refills, in addition to improving passage and connectivity for juvenile Chinook salmon (Murphy et al 2019). When considered together with RFFA 8, invasive species management, the ten drawdowns across seven reservoirs under Alternative 3a would result in indirect, beneficial, additive, and minor cumulative effects to recreational fishing and the recreational experience in the long term.

Alternative 3a would include more recurring drawdowns than Alternatives 1, 2a, or 2b. Adverse cumulative effects would be less severe than Alternative 3b but more severe than Alternatives 1, 2a, 2b, 4, and 5.

### 4.14.9 Alternative 3b – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)

Alternative 3b would improve fish passage by using operations-focused measures (using a deep drawdown to Cougars Dam's DT). Augmenting gravel below dams (#384); maintaining or altering revetments (#9); maintaining existing and new fish release sites (#726); providing Pacific lamprey passage and infrastructure (#52); operation, maintenance, repair, replacement, and rehabilitation; and constructing AFFs (#722) would have negligible to moderate adverse effects on the recreational experience in the short and medium term due to increases in noise, air emissions, visual intrusions, and traffic. In the long term, recreational fishing could benefit indirectly. Modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 9, climate change; and RFFA 10, mining operations in combination with the above-listed structural measures under Alternative 3b would have negligible to moderate cumulative and additive effects on the recreational experience in the short, medium, and long term. In the long term, the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar (specifically) in combination with the proposed measures (except for providing Pacific lamprey passage and infrastructure and Operation, Maintenance, Repair, Replacement and Rehabilitation) would have beneficial, minor, additive, cumulative effects on recreational fishing.

Using the spillway for surface spill, augmenting instream flows by using the inactive pool and the power pools, and the integrated habitat and flow regime would have indirect, beneficial, and minor effects in the long term. These measures in combination with RFFA 6, fishery management and killer whales, RFFA 7, tribal, state, and local fish and wildlife improvement, and RFFA 8, invasive species management would have minor, beneficial, additive, cumulative effects in the long term due to vegetation and habitat improvement projects.

As discussed above in Section 4.14.2.3, when considered in tandem with RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change, the ten drawdowns at seven reservoirs as well as the suite of near-term operations would create adverse, additive, and major cumulative effects to recreational experiences and opportunities. Because visitation to reservoirs would decrease during drawdowns, the provision of additional recreational opportunities from RFFA 5, federal and state wildlife and lands management would have interactive, countervailing cumulative effects on recreation.

As discussed above in 4.14.2.3, drawdowns at other reservoirs have been used to control invasive plants, which can also benefit fisheries (MWRA 2021; Cooke 1980). At Fall Creek in particular, the drawdown has shown to reduce the abundance of warm-water invasive fishes in the reservoir after it refills, in addition to improving passage and connectivity for juvenile Chinook salmon (Murphy et al 2019). When considered together with RFFA 8, invasive species management, the ten drawdowns across seven reservoirs under Alternative 3b would result in indirect, beneficial, additive, and minor cumulative effects to recreational fishing and the recreational experience in the long term.

Although Alternative 3b would include the same number of recurring drawdowns as Alternative 3a, it's cumulative effects would be more severe (slightly) due to the additional bridge and tower construction project required to draw-down the Cougar Reservoir to the DT. Under Alternative 3b, adverse cumulative effects would be more severe than any other action alternative due to the number of recurring drawdowns.

### 4.14.10 Alternative 4 – Improve Fish Passage with Structures-Based Approach

Alternative 4 would improve fish passage with structures-based measures. Adverse effects from augmenting gravel below dams (#384); maintaining or altering revetments (#9); maintaining existing and new fish release sites (#726); restoring upstream and downstream passage at drop structures (#639); providing Pacific lamprey passage and infrastructure (#52); operation, maintenance, repair, replacement and rehabilitation; structural improvements to reduce total dissolved gas (#174); constructing WTC Towers (#105), AFFs (#722), and structural downstream fish passage (#392); and the Foster Fish Ladder Temperature Improvement (#479) would have negligible to moderate adverse effects on the recreational experience in the short and medium term due to increases in noise, air emissions, visual intrusions, and traffic. In the long term, recreational fishing could benefit indirectly. Modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 9, climate change; and RFFA 10, mining operations in combination with the above-listed structural measures under Alternative 4 would have negligible to moderate cumulative and additive effects on the recreational experience in the short, medium, and long term. In the long term, the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar (specifically) in combination with the proposed measures (except for providing Pacific lamprey passage and infrastructure and Operation, Maintenance, Repair, Replacement and Rehabilitation) would have beneficial, minor, additive, cumulative effects on recreational fishing.

Augmenting instream flows by using the inactive and power pools and the integrated habitat and flow regime would have indirect, beneficial, and minor effects in the long term. These measures in combination with RFFA 6, fishery management and killer whales, RFFA 7, tribal, state, and local fish and wildlife improvement, and RFFA 8, invasive species management would have minor, beneficial, additive, cumulative effects in the long term due to vegetation and habitat improvement projects.

As discussed above in Section 4.14.2.3, when considered in tandem with RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change, the recurring Fall Creek Drawdown would create adverse, additive, and major cumulative effects to recreational experiences and opportunities. Because visitation to reservoirs would decrease during drawdowns, the provision of additional recreational opportunities from RFFA 5, federal and state wildlife and lands management would have interactive, countervailing cumulative effects on recreation.

As discussed above in 4.14.2.3, drawdowns at other reservoirs have been used to control invasive plants, which can also benefit fisheries (MWRA 2021; Cooke 1980). At Fall Creek in particular, the drawdown has shown to reduce the abundance of warm-water invasive fishes in the reservoir after it refills, in addition to improving passage and connectivity for juvenile Chinook salmon (Murphy et al 2019). When considered together with RFFA 8, invasive species management, the Fall Creek and Green Peter drawdowns would result in indirect, beneficial, additive, and minor cumulative effects to recreational fishing and the recreational experience in the long term.

Under Alternative 4, adverse cumulative effects would be more severe than alternatives 1, 2a, 2b, and 5 due to the number of construction projects, but less severe than alternatives 3a and 3b due to the number of recurring drawdowns.

### 4.14.11 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)

Alternative 5 would only differ from Alternative 2b by way of the refined integrated temperature management and habitat flow regime measure (#30b), which would not have noticeable effects on recreation. Therefore, the effects of Alternative 5 would be identical to those of Alternative 2b. Augmenting gravel below dams (#384); maintaining or altering revetments (#9); maintaining existing and new fish release sites (#726); providing Pacific lamprey passage and infrastructure (#52); operation, maintenance, repair, replacement, and rehabilitation; constructing WTC Towers (#105), AFFs (#722), and structural downstream fish passage (#392); and the Foster Fish Ladder Temperature Improvement (#479) would have negligible to moderate effects on the recreational experience in the short and medium term due to increases in noise, air emissions, visual intrusions, and traffic. In the long term, recreational fishing could benefit indirectly. Modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 9, climate change; and RFFA 10, mining operations in combination with the structural measures under Alternative 5 would have negligible to moderate cumulative and additive effects on the recreational experience in the short, medium, and long term. In the long term, the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar (specifically) in combination with the proposed measures (except for providing Pacific lamprey passage and infrastructure and Operation, Maintenance, Repair, Replacement and Rehabilitation) would have beneficial, minor, additive, cumulative effects on recreational fishing.

Augmenting instream flows by using the inactive and power pools and the refined integrated habitat and flow regime would have indirect, beneficial, and minor effects in the long term. These measures in combination with RFFA 6, fishery management and killer whales, RFFA 7, tribal, state, and local fish and wildlife improvement, and RFFA 8, invasive species management would have minor, beneficial, additive, cumulative effects in the long term due to vegetation and habitat improvement projects.

As discussed above in Section 4.14.2.3, when considered in tandem with RFFA 3, water withdrawals for municipal, industrial, and agricultural uses and RFFA 9, climate change, the drawdowns at Cougar, Fall Creek, and Green Peter and the suite of near-term operations would create adverse, additive, and major cumulative effects to recreational experiences and opportunities. Because visitation to reservoirs would decrease during drawdowns, the provision of additional recreational opportunities from RFFA 5, federal and state wildlife and lands management would have interactive, countervailing cumulative effects on recreation.

As discussed above in 4.14.2.3, drawdowns at other reservoirs have been used to control invasive plants, which can also benefit fisheries (MWRA 2021; Cooke 1980). At Fall Creek in particular, the drawdown has shown to reduce the abundance of warm-water invasive fishes in the reservoir after it refills, in addition to improving passage and connectivity for juvenile Chinook salmon (Murphy et al 2019). When considered together with RFFA 8, invasive species management, the drawdowns at Cougar, Fall Creek, and Green Peter would result in indirect, beneficial, additive, and minor cumulative effects to recreational fishing and the recreational experience in the long term.

Under Alternative 5, adverse effects would be the same as Alternative 2b, more severe than Alternatives 1, 2a, and 4, and less severe than Alternatives 3a, and 3b.

#### 4.14.12 Summary

The cumulative effects on the recreational experience would be additive, adverse, and negligible to moderate in the short, medium, and long term under all alternatives from construction projects when considered in combination with transportation and residential development, potential mining operations, climate change, and the construction or modification of WVS structures. There would also be adverse, additive, and major cumulative effects in the long term from recurring drawdowns when considered in tandem with water withdrawals for municipal, industrial, and agricultural uses and climate change. Because visitation to reservoirs would decrease during drawdowns, the provision of additional recreational opportunities from federal and state wildlife and lands management would have interactive, countervailing cumulative effects, and In the long term, all alternatives would have beneficial, minor, additive, cumulative effects on recreational fishing and the recreational experience. However, effects would still be major and adverse overall. Alternative 1 would have the least-severe adverse effects, followed by Alternatives 2a, 2b, 4, 3a, and 3b, primarily due to the number of recurring drawdowns and secondarily due to the number of short- and medium-term construction projects.

## 4.15 LAND USE

This section discusses the cumulative effects on land use. This includes a discussion of the effects of proposed measures considered alongside applicable cumulative actions, and how each project alternative would cumulatively affect land use. The geographic scope for land use would be the same boundary as described in the Affected Environment in Chapter 3, which is the entire WRB including all twelve of its sub-basins, even those that do not include a USACE dam.

### 4.15.1 Cumulative Actions Applicable to Land Use

Past, present, and reasonably foreseeable future actions that, when considered together with the Proposed Action and alternatives, would have cumulative effects on land use, include:

- Construction of the WVS dams, non-USACE dams, and supporting structures;
- Transportation corridor development;
- RFFA 1, future population growth and accompanying urban, industrial, and commercial development;
- RFFA 3, water withdrawals for municipal, industrial, and agricultural uses;
- RFFA 5, federal and state wildlife and lands management;
- RFFA 7, tribal, state, and local fish and wildlife improvement;
- RFFA 9, climate change;
- RFFA 10, mining operations;
- RFFA 11, timber and logging industry operations.

The construction of the WVS dams, non-USACE dams, and supporting structures had major impacts to land use at the time of construction because land was inundated with water and its use was changed in the long term. Past agricultural, urban, transportation, and floodplain development also had major impacts to land use as previously unaltered lands were developed for various uses. This analysis focuses on ongoing, present, and future actions, rather than past actions, to allow for a greater emphasis on future effects.

The future structural improvements at Dexter, Big Cliff, and Cougar would not have effects on land use. Other RFFAs discussed in Section 4.2.3 that would not have effects on land use include: RFFA 2, reduced agricultural production RFFA 4, decarbonizing the energy sector with renewable energy sources; RFFA 6, fishery management and killer whales; and RFFA 8, invasive species management. RFFA 4, decarbonizing the energy sector with renewable energy sources, could have an effect on land use, however, there are no proposed renewable energy projects in the WRB. RFFA 6 primarily relates to managing fisheries, subsequently, these RFFAs would not contribute to cumulative effects on land use. RFFA 8, invasive species management, could alter the type of plants contributing to land cover, but not affect the land cover type, thus it would not have cumulative effects on land use.

### *4.15.2* Discussion of Cumulative Effects by Measure(s)

This section considers the proposed measures with applicable cumulative actions to determine the potential cumulative effect to land use. Where possible, the discussion of cumulative effects is grouped by measures that would have similar effects.

#### *4.15.2.1 Restore upstream and downstream passage at drop structures (#639) and Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9)*

As discussed in Sections 3.15.4.3.1 and 3.15.4.3.2, effects from restoring upstream and downstream passage at drop structures and maintaining revetments using nature-based engineering or altering revetments for aquatic ecosystem restoration would be minor in magnitude, regional in extent, and long term in duration.

RFFA 5, federal and state wildlife and lands management, involves designating and managing lands such as wildlife refuges and national forests. Upcoming potential and ongoing federal and state wildlife and lands management activities in the WRB include improvements at the Wapato Lake National Wildlife Refuge, where the Fish and Wildlife Service would restore native plant communities, and the post-fire restoration of the Santiam State Forest (Mullan, 2021; ODF, No date). These activities would result in very noticeable improvements to land cover on a regional level, and thus, provide major cumulative effects on a regional level. Restoring upstream and downstream passage at drop structures and maintaining revetments using nature-based engineering methods would result in a minor contribution to the major cumulative effects to land cover occurring in the WRB. Therefore, when considered in tandem with applicable cumulative actions, restoring upstream and downstream passage at drop structures and maintaining revetments using nature-based engineering methods would result in additive and major cumulative effects to land cover.

#### *4.15.2.2 Construct Adult fish facilities (#722)*

As discussed in Section 3.15.4.3.3, effects from constructing AFFs would be minor in magnitude, localized in extent, and long term in duration. The results of future population growth and accompanying urban, industrial, and commercial development, climate change, mining operations, and timber and logging industry operations would have similar effects to those of constructing adult fish facilities.

Land use trends in the WRB from the 1970s to 2019 have resulted in a three percent increase in developed land and an 11 percent decrease in forest cover, while agriculture has stayed nearly the same between 21 and 22 percent (NLCD, 2019). The historic loss of forests is attributed to logging and wildfires (Oregon Wild, 2019; OFRI, 2014), but mining could have also played a minor role, especially if open pits were used. No new mine sites or logging operations have been proposed in the WRB, so these are less likely to contribute to cumulative effects to land cover and land use than other applicable RFFAs. As discussed above in Section 3.15.4.4.1, climate change is expected to exacerbate the intensity and frequency of wildfires, floods, and landslides in the future. These natural disasters would result in land use changes through expanding development (from housing relocation) and may include rerouting roads and making changes to county or local land use plans as applicable. Floodplains may also be re-mapped in order to restrict development.

As described above in Section 3.15, WRB land development has been occurring most rapidly along the I-5 corridor parallel to the mainstem Willamette River. This includes the cities of Corvallis, Eugene, and Portland, all of which will continue to develop over time. These land use trends are independent of USACE's O&M of the WVS. However, the past actions of constructing and operating dams along the Willamette River's tributaries have contributed to the development of rural land by creating desirable lakefront real estate, although lakefront development is likely of "low intensity" (i.e., less densely developed than other types of urban cover). Land development has been occurring less rapidly in rural areas, such as those surrounding WVS reservoirs. Among the thirteen WVS reservoirs, nine are less developed than the others, including: Big Cliff, Blue River, Cottage Grove, Cougar, Dorena, Fall Creek, Green Peter, Hills Creek, and Lookout Point. While there are no cities directly on their shores, many have shorelines with at least some residential development. The remaining reservoirs of Detroit, Dexter, Fern Ridge, and Foster have the towns of Detroit, Lowell, Veneta, and Sweet Home on their shores, respectively. The populations of these towns range from 80 to 10,000. Land surrounding these reservoirs would continue to be slowly developed.

As discussed in Section 3.15.2, developed land in the WRB is at approximately 94 percent of the limit imposed by the Oregon Statewide Planning Program's Urban Growth Boundary. Effects from future population growth and accompanying urban, industrial, and commercial development, climate change, mining operations, and timber and logging industry operations together would be highly conspicuous and have substantial consequences on a regional level by developing areas of land. Therefore, the effects would be major in magnitude. However, constructing AFFs would only develop up to three acres per facility, so it would result in a negligible contribution to the cumulative effects to land cover or use occurring in the WRB. This is because, when land would be developed for AFFs, it would be similar to and consistent with the adjacent uses at the nearby dam and reservoir. These developments would not be residential, commercial, or industrial; and thus, would not be the type of development that would have a "multiplier" effect, i.e., increase the demand for infrastructure, goods, and services such as water, power, and roads. Therefore, when considered in tandem with applicable cumulative actions, constructing AFFs would create additive, and major cumulative effects to land cover. Any land development under the action alternatives would represent a considerably small contribution to the overall cumulative effects compared to all cumulative actions within the WRB as a whole.

#### *4.15.2.3 Deeper fall reservoir drawdowns for fish passage (#40), Spring reservoir drawdown for downstream fish passage (#720), and Fall Creek drawdown*

As discussed in Section 3.15.4.3.4, the effects of drawing down reservoirs for fish passage would be moderate in magnitude, localized in extent, and long-term recurring in duration. The results of future population growth and accompanying urban, industrial, and commercial development; water withdrawals for municipal, industrial, and agricultural uses; and climate change would have similar effects on land use as drawing down the reservoirs in the fall and spring for fish passage.

Very limited aspects of RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 3, water withdrawals for municipal, industrial, and agricultural uses; and RFFA 9, climate change, would have similar effects on land cover as reservoir drawdowns. These RFFAs would have similar effects on water levels water levels. As populations increase, water withdrawals for municipal, industrial, and agricultural uses would increase proportionally as more humans would require more water and water-demanding agriculture. The increase in the demand for water would strain reservoir storage and could reduce average annual water levels over time, resulting in decreased open water land coverage. Climate change is expected to exacerbate these effects by creating longer and more arid drought seasons and smaller snowpacks. Increasing air temperatures would also contribute to lower water levels by increasing evaporation rates. When considered in tandem with each other, RFFAs 1, 2, 3, and 9 would contribute to less open water land cover, and thus, would be exacerbated by reservoir drawdowns. In the short and medium terms, reservoir drawdowns would be much more noticeable than the effects of RFFAs 1, 2, 3, and 9 on open water coverage, but over time, would increasingly contribute to the decline of open water coverage. Therefore, when considered in tandem with applicable cumulative actions, reservoir drawdowns would create additive, and moderate cumulative effects on land cover.

### *4.15.3* Discussion of Cumulative Effects by Alternative

This section analyzes the relevant cumulative actions by alternative to determine the potential cumulative effects to land use.

#### *4.15.3.1 No Action Alternative*

Under the NAA, the existing O&M of the WVS would continue. The Fall Creek Reservoir is annually drawn down to levels near the historic streambed to assist juvenile fish passage. As described in Section 4.3.15.2.4, when considered in tandem with applicable cumulative actions, recurring drawdowns would create additive, and moderate cumulative effects to land use.

#### *4.15.3.2 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Alternative 1 would include restoring upstream and downstream passage at drop structures, maintaining or altering revetments, constructing an AFF, and continuing the Fall Creek drawdown. As discussed above in Sections 4.15.2.1 through 4.15.2.3, effects would be minor in magnitude, regional in extent, and long-term in duration for restoring upstream and downstream passage and maintaining or altering revetments; minor in magnitude, localized in extent, and long term for constructing an AFF; and moderate in magnitude, localized in extent, and long-term recurring for drawdowns. Cumulative effects would be less than Alternatives 2a, 2b, 3a, 2b, 4, and 5.

#### *4.15.3.3 Alternative 2a –Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam)*

Alternative 2a would include maintaining or altering revetments, constructing an AFF, drawing down reservoirs in the fall for fish passage, and continuing the Fall Creek drawdown. As discussed above in Sections 4.3.15.2.1 through 4.3.15.2.3, effects would be minor in magnitude, regional in extent, and long-term in duration for restoring upstream and downstream passage and maintaining or altering revetments; minor in magnitude, localized in extent, and long term for constructing an AFF; and moderate in magnitude, localized in extent, and long-term recurring for drawdowns. Cumulative effects would be greater than Alternatives 1 and 4, but less than Alternatives 2b, 3a, 3b, and 5.

#### *4.15.3.4 Alternative 2b – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 2b would include maintaining or altering revetments, constructing an AFF, drawing down reservoirs in the fall for fish passage, drawing down reservoirs in the spring for fish passage, and continuing the Fall Creek drawdown. As discussed above in Sections 4.3.15.2.1 through 4.3.15.2.3, effects would be minor in magnitude, regional in extent, and long-term in duration for restoring upstream and downstream passage and maintaining or altering revetments; minor in magnitude, localized in extent, and long term for constructing an AFF; and moderate in magnitude, localized in extent, and long-term recurring for drawdowns. Cumulative effects would be greater than Alternatives 1, 2a, and 4, the same as Alternative 5, and less than Alternatives 3a, and 3b.

#### *4.15.3.5 Alternative 3a – Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)*

Alternative 3a would include maintaining or altering revetments, constructing AFFs, drawing down reservoirs in the fall for fish passage, drawing down reservoirs in the spring for fish passage, and continuing the Fall Creek drawdown. As discussed above in Sections 4.3.15.2.1 through 4.3.15.2.3, effects would be minor in magnitude, regional in extent, and long-term in duration for restoring upstream and downstream passage and maintaining or altering revetments; minor in magnitude, localized in extent, and long term for constructing an AFF; and moderate in magnitude, localized in extent, and long-term recurring for drawdowns. Cumulative effects would be the same as Alternative 3b and greater than Alternatives 1, 2a, 2b, 4, and 5.

#### *4.15.3.6 Alternative 3b – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)*

Alternative 3b would include maintaining or altering revetments, constructing AFFs, drawing down reservoirs in the fall for fish passage, drawing down reservoirs in the spring for fish passage, and continuing the Fall Creek drawdown. As discussed above in Sections 4.3.15.2.1 through 4.3.15.2.3, effects would be minor in magnitude, regional in extent, and long-term in duration for restoring upstream and downstream passage and maintaining or altering revetments; minor in magnitude, localized in extent, and long term for constructing an AFF; and moderate in magnitude, localized in extent, and long-term recurring for drawdowns. Cumulative effects would be the same as Alternative 3a and greater than Alternatives 1, 2a, 2b, 4, and 5.

#### *4.15.3.7 Alternative 4 – Improve Fish Passage with Structures-Based Approach*

Alternative 4 would include restoring upstream and downstream passage at drop structures, maintaining or altering revetments, constructing an AFF, and continuing the Fall Creek drawdown. As discussed above in Sections 4.3.15.2.1 through 4.3.15.2.3, effects would be minor in magnitude, regional in extent, and long-term in duration for restoring upstream and downstream passage and maintaining or altering revetments; minor in magnitude, localized in extent, and long term for constructing an AFF; and moderate in magnitude, localized in extent, and long-term recurring for drawdowns. Cumulative effects would be greater than Alternative 1 and less than Alternatives 2a, 2b, 3a, 3b, 4, and 5.

#### *4.15.3.8 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 5 would only differ from Alternative 2b by way of the refined integrated temperature management and habitat flow regime measure (#30b), which is not a measure that would have effects on land cover. Therefore, the effects of Alternative 5 would be identical to those of Alternative 2b; and thus, would be greater than Alternatives 1, 2a, and 4, and less than Alternatives 3a, and 3b.

### *4.15.4* Summary

The cumulative effects of each of the alternatives would be additive and major from constructing AFFs when considered in tandem with land development occurring in the WRB. Cumulative effects would be adverse, additive, and moderate from recurring drawdowns, and would be additive, and major from restoring downstream passage at drop structures and maintaining or altering revetments when considered in tandem with federal and state wildlife and lands management. Alternative 1 would have the least-severe effects, followed by Alternatives 4, 2a, 2b and 5, 3a, and 3b due to the number of recurring drawdowns and AFFs constructed.

## 4.16 HAZARDOUS MATERIALS

This section discusses the cumulative effects from hazardous materials. This includes a discussion of the effects of proposed measures considered alongside applicable cumulative actions, and how each project alternative would cumulatively contribute to the emission, discharge, or deposition of hazardous materials in soil, sediment, air, and/or water. The geographic scope for hazardous materials would be the same boundary as described in the Affected Environment in Chapter 3.

### *4.16.1* Cumulative Actions Applicable to Hazardous Materials

Past, present, and reasonably foreseeable future actions that, when considered together with the Proposed Action and alternatives, would have cumulative effects from hazardous materials, include:

- Construction of the WVS dams, non-USACE dams, and supporting structures;
- Proliferation of invasive species;
- Ongoing and present structural improvements;
- RFFA 8, invasive species management; and
- RFFA 9, climate change.

The initial construction of the WVS dams, non-USACE dams, and supporting structures occurred over 80 years ago, but created a system that requires the use of hazardous materials for activities such as construction, demolition, and maintenance (which requires the storage and use of compressed gasses, management of LBP and ACM, and other hazardous materials); O&M of fish collection and hatchery facilities; and the O&M of oil-filled equipment. Additionally, the proliferation of invasive species has required pesticides to be used basin-wide in the WVS on an as needed basis. The hazardous materials used in the O&M of the WVS are described in greater detail in Section 3.16.2.3. This analysis focuses on ongoing, present, and future actions, rather than past actions, to allow for a greater emphasis on future effects.

Some of the RFFAs discussed above in Section 4.2.3, such as RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 10, mining operations; and RFFA 11, timber and logging industry operations, may appear to contribute to effects from hazardous materials. However, these actions are occurring outside of the WVS (the system of 13 dams and reservoirs), and instead, are occurring in the larger region of the WRB. Because the area of analysis for hazardous materials has been defined as the WVS (Section 3.16), these RFFAs would not contribute to effects from hazardous materials *in the WVS* and therefore, are not discussed further in this section. Effects from *hazardous wastes* are considered in Section 3.18, Public Health and Safety – Hazardous, Toxic, and Radioactive Waste as applicable, which has a larger area of analysis than hazardous materials.

Other RFFAs would not contribute to effects from hazardous materials because they are generally not applicable, and therefore, are not discussed further. These include RFFA 2, reduced agricultural production; RFFA 3, water withdrawals for municipal, industrial, and agricultural uses; RFFA 4, decarbonizing the energy sector with renewable energy sources; RFFA 5, federal and state wildlife and lands management; RFFA 6, fishery management and killer whales; and RFFA 7, tribal, state, and local fish and wildlife improvement.

### *4.16.2* Discussion of Cumulative Effects by Measure(s)

This section considers the proposed measures with applicable cumulative actions to determine the potential cumulative effect from hazardous materials. Where possible, the discussion of cumulative effects is grouped by measures that would have similar effects. The discussion of cumulative effects below does not include adapting the hatchery program because it is the only measure that would have beneficial effects, and no cumulative actions would contribute to beneficial effects from hazardous materials.

#### *4.16.2.1 Continued Operation of Existing AFFs, Gravel augmentation below dams (#384), Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), Maintenance of existing and new fish release sites above dams (#726), Restore upstream and downstream passage at drop structures (#639), Provide Pacific lamprey passage and infrastructure (#52), Use spillway for surface spill in summer (#721), Structural improvements to reduce total dissolved gas (#174), Foster Fish Ladder Temperature Improvement (#479), Construct AFF (#722), Construct water temperature control tower (#105), Deeper fall reservoir drawdowns for fish passage (#40), Construct structural downstream fish passage (#392), and a Suite of near-term operations*

As discussed in Section 3.16.2.4, the effects of these measures would be negligible to minor in magnitude, adverse, and local to regional in extent in the short, medium, and long term. These effects would be caused by the use of hazardous materials for construction, operation, and maintenance activities, and would be mitigated by adhering to applicable environmental laws and regulations and following BMPs. The results of ongoing and present structural improvements would have similar effects from hazardous materials because they would involve construction.

The ongoing and present structural improvement projects at Dexter, Big Cliff, and Cougar could require hazardous materials such as diesel and gasoline for fueling equipment and compressed gasses for welding, cutting, and brazing. They also may involve the management of LBP and ACM, fish collection and hatchery chemicals, and the operation of oil-filled equipment. However, as discussed above in Section 3.16.2.3, effects from hazardous materials would be mitigated by adhering to the USACE Hazard Communication Plan (which includes training and wearing PPE as applicable) and the requirements for compressed gasses and welding, cutting, and brazing in 29 CFR parts 1910.101 and 1910.253. Further, BMPs would be followed, such as maintaining a clean working environment and adhering to proper storage and fueling guidelines.

Therefore, when considered in tandem with applicable cumulative actions, these measures would create additive, negligible to minor, cumulative effects from hazardous materials.

#### *4.16.2.2 Operation, Maintenance, Repair, Replacement and Rehabilitation;*

The discussion in this subsection focuses on the *operation* and *maintenance* components of operation, maintenance, repair, replacement, and rehabilitation, with particular emphasis on pesticide use, which is the only component of hazardous materials in the WVS not discussed above in Section 3.16.2.4. As discussed above in Sections 3.19.1.7 and 3.16.2.3.1, pesticides are used basin-wide across the WVS as necessary to manage and control pest species. The results of RFFA 8, invasive species management and RFFA 9, climate change, would have similar effects from hazardous materials.

As stated in Section 3.16.2.3.1, environmental effects from pesticide use would be negligible in magnitude, adverse, and local in extent. Climate change would have no effects from hazardous materials through construction, demolition, and repair of buildings and structures, storage and use of compressed gasses, fish collection and hatchery chemicals, management of LBP and ACM, or operation of oil-filled equipment at hydroelectric dams. However, the proliferation of invasive species/invasive species management and climate change may interact additively or synergistically with hazardous materials.

Human activity has led to the spread of invasive species, particularly in water bodies, as boats can accidentally transport and spread species if boats and equipment are not thoroughly cleaned. Wetter winters and drier summers would also be expected to lead to changes in vegetation community composition and distribution over time, as drought-tolerant species become predominant and invasive plants potentially spread further into or take over communities of native species, as discussed in Section 3.06, Vegetation. Climate change would exacerbate the spread of invasive species (both plants and animals) facilitated by human activity.

If invasive species proliferate throughout the WVS over time as a result of human activity and anthropogenic climate change, the quantity of pesticides used to control them could increase proportionally. As discussed above in Section 3.16.1.1 and detailed in the Hazard Communication Plan, USACE personnel are informed of and able to identify hazardous chemicals, as well as protect themselves from hazardous chemical exposures using PPE. Further, pesticides are securely stored, many are considered non-hazardous, and the majority of applications are away from water. Therefore, when considered in tandem with applicable cumulative actions, operation, maintenance, repair, replacement, and rehabilitation would likely create additive, negligible, cumulative effects from hazardous materials.

### 4.16.3 Discussion of Cumulative Effects by Alternative

This section analyzes the relevant cumulative actions by alternative to determine the potential cumulative effects to hazardous materials.

#### *4.16.3.1 No Action Alternative*

Under the NAA, the existing O&M of the WVS would continue. The O&M of the WVS includes construction, demolition, and maintenance (which requires the storage and use of compressed gasses, management of LBP and ACM, and other hazardous materials); fish collection and hatchery chemicals; pesticides; and the operation of oil-filled equipment. As discussed above in Sections 4.16.2.1 and 4.16.2.2, when considered in tandem with applicable cumulative actions, these activities would create negligible to minor in magnitude, adverse, cumulative effects from hazardous materials.

#### *4.16.3.2 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Alternative 1 would combine storage-focused measures in order to improve fish passage. As discussed above in Sections 4.16.2.1 and 4.16.2.2, when considered in tandem with applicable cumulative actions, these activities would create negligible to minor in magnitude, adverse, cumulative effects from hazardous materials.

Although not appreciable, cumulative effects would be greater than Alternatives 2a, 2b, 3a, 3b, and 5, but less than Alternative 4. All alternatives, including the NAA, include the management and use of hazardous materials. Any hazardous materials required under Alternative 1, either in the short-, medium-, or long-term, would represent a considerably small contribution to environmental effects from hazardous materials in the WVS.

#### *4.16.3.3 Alternative 2a – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam)*

Alternative 2a would integrate water management flexibility and ESA-listed fish measures (using structural downstream passage at Cougar Dam). As discussed above in Sections 4.16.2.1 and 4.16.2.2, when considered in tandem with applicable cumulative actions, these activities would create negligible to minor in magnitude, adverse, cumulative effects from hazardous materials.

Cumulative effects would be the same as Alternative 3a, greater than Alternatives 2b and 5, but less than Alternatives 1, 3b, and 4. Any hazardous materials required under Alternative 2a, either in the short-, medium-, or long-term, would represent a considerably small contribution to environmental effects from hazardous materials in the WVS.

#### *4.16.3.4 Alternative 2b – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 2b would integrate water management flexibility and ESA-listed fish measures (using a deep drawdown to Cougar Dam's DT). As discussed above in Sections 4.16.2.1 and 4.16.2.2, when considered in tandem with applicable cumulative actions, these activities would create negligible to minor in magnitude, adverse, cumulative effects from hazardous materials.

Cumulative effects would be the same as Alternative 5 and less than all other action alternatives because these alternatives include the fewest short- and medium-term construction projects. Any hazardous materials required under Alternative 2b, either in the short-, medium-, or long-term, would represent a considerably small contribution to environmental effects from hazardous materials in the WVS.

#### *4.16.3.5 Alternative 3a – Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)*

Alternative 3a would improve fish passage by using operations-focused measures (using a deep drawdown to Cougars Dam's RO). As discussed above in Sections 4.16.2.1 and 4.16.2.2, when considered in tandem with applicable cumulative actions, these activities would create negligible to minor in magnitude, adverse, cumulative effects from hazardous materials.

Cumulative effects would be the same as Alternative 2a, greater than Alternatives 2b and 5, and less than Alternatives 1, 3b, and 4. Any hazardous materials required under Alternative 3a, either in the short-, medium-, or long-term, would represent a considerably small contribution to environmental effects from hazardous materials in the WVS.

#### *4.16.3.6 Alternative 3b – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)*

Alternative 3b would improve fish passage by using operations-focused measures (using a deep drawdown to Cougar Dam's DT). As discussed above in Sections 4.16.2.1 and 4.16.2.2, when considered in tandem with applicable cumulative actions, these activities would create negligible to minor in magnitude, adverse, cumulative effects from hazardous materials.

Cumulative effects would be greater than Alternatives 2a, 2b, and 5, but less than Alternatives 1 and 4. Any hazardous materials required under Alternative 3b, either in the short-, medium-, or long-term, would represent a considerably small contribution to environmental effects from hazardous materials in the WVS.

#### *4.16.3.7 Alternative 4 – Improve Fish Passage with Structures-Based Approach*

Alternative 4 would improve fish passage with structures-based measures. As discussed above in Section 4.16.2, the effects of these measures would be negligible in magnitude, adverse, and local in extent in the short, medium, and long term.

Cumulative effects would be greater than all other action alternatives due to the number of medium-term construction projects that would occur. Any hazardous materials required under Alternative 4, either in the short-, medium-, or long-term, would represent a considerably small contribution to environmental effects from hazardous materials in the WVS; however, it would be a greater contribution than any of the other action alternatives.

#### *4.16.3.8 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 5 would only differ from Alternative 2b by way of the *refined* integrated temperature management and habitat flow regime measure (#30b), which is not a measure that would have effects from hazardous materials. Therefore, the effects of Alternative 5 would be identical to those of Alternative 2b: negligible to minor in magnitude, and less than all other action alternatives because these alternatives include the fewest short- and medium-term construction projects.

### 4.16.4 Summary

The cumulative effects under all alternatives would be adverse, additive, and negligible to minor from construction measures, especially those with long-term operational effects after initial construction, when considered in tandem with the structural improvement projects at Dexter, Big Cliff, and Cougar. Alternative 2b and 5 would have the least-severe adverse effects, followed by Alternatives 2a, 3a, 3b, 1, and 4.

## 4.17 HARMFUL ALGAL BLOOMS

This section discusses the cumulative effects of harmful algal blooms (HABs) on public health and safety. This includes a discussion of the effects of proposed measures considered alongside applicable cumulative actions, and how each project alternative would cumulatively affect public health and safety as related to HABs. The geographic scope for public health and safety - HABs would be the same boundary as described in the Affected Environment in Chapter 3, which includes the 13 dams, reservoirs, and downstream reaches within the WRB.

### 4.17.1 Cumulative Actions Applicable to Public Health and Safety – HABs

Past, present, and reasonably foreseeable future actions that, when considered together with the Proposed Action and alternatives, would have cumulative effects from public health and safety - HABs, include:

- Construction of the WVS dams, supporting structures, and non-USACE dams;
- Water quality management;
- Agricultural, urban and transportation corridor development;
- Water withdrawals for irrigation, municipal, and industrial uses to support human development in the Willamette Valley;
- Floodplain development;
- Dredging and sediment management;
- Point and non-point source water pollution;
- RFFA 1, future population growth and accompanying urban, industrial, and commercial development;
- RFFA 2, reduced agricultural production;
- RFFA 3, water withdrawals for municipal, industrial, and agricultural uses;
- RFFA 5, federal and state wildlife and lands management;
- RFFA 7, tribal, state, and local fish and wildlife improvement;
- RFFA 8, invasive species management;
- RFFA 9, climate change; and
- RFFA 10, mining operations.

Other RFFAs discussed in Section 4.1 would not have a cumulative effect on public health and safety - HABs. These include RFFA 4, decarbonizing the energy sector with renewable energy sources; RFFA 6, fishery management and killer whales; and RFFA 11; timber and logging industry operations. These actions do not contribute to land development and the subsequent water pollution in the watershed that discharges to the reservoirs cumulatively lead to HABs;

thus, these RFFAs were dismissed from further analysis. RFFA 11 was dismissed from further analysis because timber and logging operations do not occur within the WRB.

### 4.17.2 Discussion of Cumulative Effects by Measure(s)

This section considers the proposed measures with relevant cumulative actions to determine the potential cumulative effects to public health and safety - HABs. The proposed measures analyzed in Section 3.17 and listed below would all contribute to the cumulative effects on public health and safety – HABs.

#### *4.17.2.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9); Continued Operation of Existing Adult Fish Facilities; Operation, Maintenance, Repair, Replacement, and Rehabilitation; Restore upstream and downstream passage at drop structures (#639); Construct adult fish facility (AFF) (#722); Provide Pacific lamprey passage and infrastructure (#52); and construct structural downstream fish passage (#392)*

As discussed under Section 3.17.5.3, the effects of these measures are adverse and/ or beneficial, negligible and/or minor in magnitude, small in extent, in the short term, medium term, and long term. These effects are caused by either construction of the proposed measure or maintenance activities which would be mitigated by erosion and sediment controls at the construction or maintenance site, and/or would be required to meet water quality requirements for construction discharges or effluent from fish facilities.

The ongoing and present construction of the WVS dams would continue to have similar effects as the proposed measures. Construction of the above listed measures would negligible as measures to prevent erosion and sedimentation would be implemented during construction. Therefore, when considered in tandem with applicable cumulative actions, these measures would create additive, negligible to minor, cumulative effects from public health and safety – HABs.

#### *4.17.2.2 Foster Fish Ladder Temperature Improvement (#479); Construct water temperature control (WTC) tower (#105); Structural improvements to reduce total dissolved gas (#174); Use spillway for surface spill in summer (#721), Pass water over spillway in spring for fish passage (#714); Augment instream flows by using the inactive pool (#718); Augment instream flows by using the power pool (#304); Reduce minimum flows to Congressionally authorized minimum flow requirements (#723); Fall Creek drawdown, Deeper fall reservoir drawdowns for fish passage (#40); Spring reservoir drawdown for downstream fish passage (#720); and Use regulating outlets (ROs) to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166)*

As discussed under Section 3.17.5.3, the effects of these measures are adverse and/ or beneficial, minor in magnitude, large in extent, and long term. These measures promote the continual flow and blending of water that could inhibit HABs from forming. These measures also contribute to adverse minor, large, and long-term effects due to the release of excess nutrients downstream that could cause a HABs event downstream.

The ongoing and present construction of the WVS system and water quality management would continue to have similar effects with the proposed measures. Construction measures would be mitigated as discussed above in 4.17.2.1 and the ongoing and present water quality management measures proposed would also aid in inhibiting HABs growth.

The ongoing and present land development actions discussed could however interact additively or synergistically with public health and safety – HABs. Measures which include increased development in the watershed due to population growth, such as construction of the WVS dams and non-USACE dams; agricultural, urban and transportation corridor development; water withdrawals for irrigation, municipal, and industrial uses; development of the floodplain; and point and non-point source water pollution are all activities which can lead to stormwater pollution and excessive nutrients discharging into the environment. The nutrient laden runoff from the developed land in the watershed collects in the reservoirs which can lead to HABs formation. The cumulative effects of land development actions in the watershed would be adverse and minor to major. Excess nutrients would lead to small changes in water quality or could lead to substantial changes in water quality that could cause a HABs event and unsafe exposure.

Invasive species management (RFFA 8) in the watershed would have minor to major cumulative effects due to the use of pesticides and herbicides which could further exacerbate a HABs event.

Conversely, land management and restoration for fish and wildlife (RFFA 5 and 7), as well as water quality management in the watershed, would result in beneficial direct minor to major cumulative effects on HABs occurrence as the preservation of natural land would protect water resources and reduce water pollution.

Dredging and sediment management would have direct beneficial minor to moderate effects as the sediment in the reservoir would trap nutrients. Thus, dredging sediment from the reservoirs would reduce nutrients in the reservoir which could reduce the occurrence of HABs.

Climate change would contribute to adverse moderate to major cumulative effects due to changes in temperature, precipitation and stream baseflows as described in Section 3.17.5.

Lastly, mining operations are required to meet water quality requirements for effluent and therefore would have negligible to minor adverse cumulative effects on public health and safety - HABs.

Therefore, when considered in tandem with applicable cumulative actions, these measures would create additive, negligible to major, cumulative effects on public health and safety – HABs.

#### *4.17.2.3 Integrated temperature and habitat flow regime (#30a) and Refined integrated temperature and habitat flow regime (#30b)*

As discussed under Section 3.17.5.3, the effects of these measures are beneficial, minor in magnitude, small in extent, and long term. These measures promote the continual flow and blending of water that could inhibit HABs from forming. The beneficial effects associated with land management and restoration as well as dredging and sediment management would have additive beneficial effects for the reasons discussed in 4.17.2.2 to public health and safety – HABs.

When considered in tandem with these measures, cumulative actions would have adverse and beneficial, additive, and negligible to major cumulative effects to public health and safety - HABs in the WVS.

### 4.17.3 No Action Alternative

The NAA aggregated with the cumulative effects of past, ongoing and reasonably foreseeable future actions would cause additive adverse effects due to the land development activities in the watershed, invasive species management, climate change, and mining operations and beneficial additive effects due to land management, restoration, water quality management, and dredging as discussed under Section 4.17.2.1 and 4.17.2.2. The additive effects would result in adverse and beneficial additive, negligible to major effects on the formation of HABs and public health and safety.

### 4.17.4 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures

Under Alternative 1, fish passage would be improved through storage-focused measures by maximizing refill volumes of conservation pools, tapping into the power pool, and augmenting flow to the congressionally authorized minimum flows. This would increase the likelihood of refilling to the maximum conservation pool levels as discussed under Section 2.4.3. The effects are similar to the NAA but still appreciably greater than the NAA because the reservoirs will be maximizing storage which can lead to greater nutrient accumulation in the reservoir which could lead to a HABs occurrence. The aggregated effects on Alternative 1 would result in overall adverse additive, negligible to major cumulative effects.

### 4.17.5 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative

Under Alternative 2A, integrated temperature and habitat flow regimes would be utilized as well as using the power pool to augment flows. Structural and operational measures are proposed to address water quality as well as the Near-Term Operations Measure as discussed under Section 2.2.5. These measures would have adverse and beneficial additive, negligible to major cumulative effects similar to Alternative 1 but would be appreciably less because Alternative 1 has a focus on maximizing storage which can lead to a higher accumulation of nutrients in the reservoirs and subsequent HABs occurrences.

### 4.17.6 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative

Under Alternative 2B, the cumulative effects to public health and safety - HABs would be the same as those described under Alternative 2A. The difference is that the downstream passage measure at Cougar Dam is changed from a structural fish passage structure (#392) under 2A to changing of operations to a deeper fall (#40) and spring reservoir drawdown (#720) with the construction of a diversion tunnel under 2B. These measures would contribute nearly identical adverse and beneficial, additive, negligible to major cumulative effects as Alternative 1 and 2A, however effects would overall be less than Alternative 1.

### 4.17.7 Alternative 3A – Operations-Focused Fish Passage Alternative

Under Alternative 3A, improved fish passage is proposed through the modifying of operations instead rather than focusing on storage (Alternative 1) or structural measures (Alternative 4). This alternative also includes the Near-Term Operations Measure. As discussed above in Sections 4.17.2, these measures would have adverse and beneficial, additive, negligible to major cumulative effects. Alternative 3A would have the same cumulative effect as Alternatives 1, 2A, and 2B, however effects would be overall less than Alternative 1.

### 4.17.8 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)

Under Alternative 3B, the cumulative effects to public health and safety - HABs would be the same as those described under Alternative 3A. Alternative 3B proposes the slightly different combination of operations for the downstream passage. 3A proposes the drawdown to 10 feet over the top of the Cougar Dam RO for deep fall and spring drawdown measures and 3B includes drawdown utilizing the diversion tunnel at Cougar.

As discussed above in Sections 4.17.2, these measures would contribute adverse and beneficial additive, negligible to major cumulative effects. Alternative 3B would have the same cumulative effect as Alternative 1, 2A, 2B, and 3A, however effects would be overall less than Alternative 1.

### 4.17.9 Alternative 4 – Structures-Based Fish Passage Alternative

Under Alternative 4, a structures-based approach is proposed to improve fish passage. The cumulative effects to public health and safety - HABs would be the same as those described under Alternative 2A. Alternative 4 utilizes the integrated temperature and habitat flow regime proposed in Alternative 2A and includes Near Term Operations Measures as well as structural improvements.

As discussed above in Sections 4.17.2, these measures would contribute adverse and beneficial additive, negligible to major cumulative effects. Alternative 4 would have the same cumulative effect as Alternative 1, 2A, 2B, 3A, and 3B, however effects would be overall less than Alternative 1.

### 4.17.10 Alternative 5 – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)

Under Alternative 5 – the Preferred Alternative, fish passage would be improved through a combination of modified operations and structural improvements. Alternative 5 is exactly the same as Alternative 2B except the integrated temperature and habitat flow regime (#30a) is replaced with refined integrated temperature and habitat flow regime (#30b). As discussed above in Section 4.17.2.3., these measures would have adverse and beneficial additive, negligible to major cumulative effects. Alternative 5 would have the same cumulative effects as Alternative 1, 2A, 2B, 3A, 3B and 4, however effects would be overall less than Alternative 1.

### 4.17.11 Summary

In summary, the cumulative effects of each of the alternatives would have similar adverse and beneficial additive, negligible, minor, moderate and major effects. However, Alternative 1 has appreciably greater effects than Alternatives 2A, 2B, 3A, 3B, 4 and 5 since it maximizes conservation storage as discussed in Sections 4.17.4 and 4.17.5.

## 4.18 PUBLIC HEALTH AND SAFETY – HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

This section discusses the cumulative effects on public health and safety from HTRW. This includes a discussion of the effects of proposed measures considered alongside applicable cumulative actions, and how each project alternative would cumulatively affect public health and safety from HTRW. The geographic scope for public health and safety HTRW would be the same boundary as described in the Affected Environment in Chapter 3, which is the WVS, but also includes some nearby facilities on private property within the WRB such as mines, from which contamination has migrated onto USACE property.

### 4.18.1 Cumulative Actions Applicable to Public Health and Safety – Hazardous, Toxic, and Radioactive Waste

Past, present, and reasonably foreseeable future actions that, when considered together with the Proposed Action and alternatives, would have cumulative effects on public health and safety from HTRW, include:

- Construction of the WVS dams, non-USACE dams, and supporting structures;
- Ongoing and present structural improvements;
- RFFA 1, future population growth and accompanying urban, industrial, and commercial development;
- RFFA 2, reduced agricultural production;
- RFFA 8, invasive species management;
- RFFA 9, climate change; and
- RFFA 10, mining operations.

The initial construction of the WVS dams, non-USACE dams, and supporting structures occurred over 50 years ago, but the lack of proper hazardous waste management left a legacy of contamination at eight of the WVS dams. These contamination sites pose varying risks to public health and safety and are summarized in Section 3.18.1.6. Additionally, the construction of the dams and supporting structures, specifically those that produce hydropower, created small ongoing sources of hazardous waste from the chemicals necessary for their operation, such as waste from oil used in turbines and transformers, described in further detail in Section 3.18.1.1. This analysis focuses on ongoing, present, and future actions, rather than past actions, to allow for a greater emphasis on future effects.

Some of the RFFAs discussed in Section 4.2.3 would not have an effect on public health and safety from HTRW. These include RFFA 3, water withdrawals for municipal, industrial, and agricultural uses; RFFA 4, decarbonizing the energy sector with renewable energy sources; RFFA 5, federal and state wildlife and lands management; RFFA 6, fishery management and killer whales; RFFA 7, tribal, state, and local fish and wildlife improvement; and RFFA 11, timber and logging industry operations.

### *4.18.2* Discussion of Cumulative Effects by Measure(s)

This section considers the proposed measures with applicable cumulative actions to determine the potential cumulative effect on public health and safety from HTRW. Where possible, the discussion of cumulative effects is grouped by measures that would have similar effects.

#### *4.18.2.1 Operation, Maintenance, Repair, Replacement and Rehabilitation, Use spillway for surface spill in summer (#721), Provide Pacific lamprey passage and infrastructure (#52), Foster Fish Ladder Temperature Improvement (#479), Structural improvements to reduce total dissolved gas (#174), Construct adult fish facility (#722), Construct water temperature control tower (#105), and Construct structural downstream fish passage (#392)*

As discussed in Section 3.18.2.3 the effects of these measures would primarily be negligible in magnitude, adverse, and local in extent in the short, medium, and long term. These effects would be caused by the generation of small amounts of hazardous waste from maintenance and construction activities, but would be mitigated through RCRA compliance and BMPs as discussed in Section 3.18.2.3. The results of ongoing and present structural improvements; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 8, invasive species management; and RFFA 10, mining operations, would have similar effects on public health and safety from HTRW. RFFA 2, reduced agricultural production would have countervailing beneficial effects; however, these would not be great enough to make the overall effects beneficial.

RFFAs 1, 2, 8, and 10 would also all produce hazardous waste and subsequently contribute to the risk to public health and safety. Ongoing and present structural improvements could potentially generate small amounts of hazardous waste from activities such as using compressed gasses for cutting, welding, and brazing, or could otherwise require hazardous material and generate small amounts of hazardous waste from construction activities in general. Therefore, these actions would have identical effects as described above in Section 3.18.2.3: negligible to minor in magnitude, local in extent, adverse, and short-, medium-, and/or long-term in duration.

Industrial development is a notable contributor to hazardous waste in the U.S. As populations grow, increased industrial development would result in more hazardous waste, and increase the risk to public health and safety. One indicator of facilities that produce hazardous waste is the EPA Toxics Release Inventory (TRI)[61]. Although numerous TRI-reporting-facilities exist in the WRB, there were no TRI-reporting-facilities adjacent to WVS reservoirs according to 2020 data (EPA 2020c). Invasive species management could require the management of pests with hazardous chemicals, which would generate waste when chemicals are leftover. Several WVS reservoirs have agriculture directly on their shores (primarily hay and pastureland), and pesticides are used basin-wide as necessary (NLCD 2019; USACE 2021a). The amount of

[61] TRI information is not all encompassing because facilities are only required to report when a threshold of toxic chemical use is met, typically, 10,000 pounds.

hazardous waste from leftover pesticides would decrease proportionally with reduced agricultural production, resulting in countervailing beneficial effects. However, the effects on public health and safety from this hazardous waste would be undetectable, so the overall effects would still be adverse. Mining operations also produce hazardous waste. Several production mines and active and/or closed mining claims exist near the Blue River, Detroit, Fall Creek, Foster, Green Peter, and Lookout Point reservoirs. The majority of these mines are related to gold, which is known to generate hazardous waste (The Diggings 2022; Fashola et al. 2016). Although these cumulative actions would generate hazardous waste, generators would generate and store waste in accordance with RCRA regulations, or else face steep penalties. Therefore, the risk to public health and safety would likely be near regulatory standards.

The WVS only generates small amounts of hazardous waste pursuant to CESQG generator status that would have adverse but negligible effects to public health and safety. However, when considered in tandem with applicable cumulative actions, these measures would create additive, minor to moderate cumulative effects to public health and safety from HTRW.

#### *4.18.2.2 Deeper fall reservoir drawdowns for fish passage (#40)*

Deeper fall drawdowns at the Blue River Reservoir could expose the previously inundated legacy-contaminated sediment near the saddle dam, described above in Section 3.18.2.3.5. The effects of this would be minor in magnitude, recurring in the long term, and be reduced using administrative controls as necessary. The results of RFFA 9, climate change, would have similar effects on public health and safety from HTRW. As discussed above in Section 3.18.2.4.1, climate change presents indirect risks to public health and safety from HTRW. Climate change is expected to exacerbate the frequency and severity of natural disasters such as wildfires and floods, and could increase the risk to public health by spreading or exposing contamination that had previously been inaccessible to the public. Seven superfund sites in the WRB have been found to be vulnerable to climate change, including one adjacent to the mainstem Willamette River (Hasemeyer and Olsen 2020).

Other waste sites that are not classified as superfund sites but could potentially be vulnerable to climate change are those at Big Cliff, Blue River, Cougar, Detroit, Dexter, Dorena, Fall Creek, and Green Peter, described in Section 3.18.1.6. However, deeper fall drawdowns for fish passage would only pose risks for three weeks out of the year at one location, so it would result in a minor contribution to the overall adverse cumulative effects to public health and safety from HTRW occurring in the WVS.

Therefore, when considered in tandem with applicable cumulative actions, deeper fall reservoir drawdowns for fish passage would create additive, minor, cumulative effects to public health and safety from HTRW.

### *4.18.3* Discussion of Cumulative Effects by Alternative

This section analyzes the relevant cumulative actions by alternative to determine the potential cumulative effects to Public Health and Safety - HTRW.

#### *4.18.3.1 No Action Alternative*

Under the NAA, the existing O&M of the WVS would continue. The O&M of the WVS generates small amounts of hazardous waste as described in section 3.18.2.4, which would result in negligible effects to public health and safety because the management of the waste would comply with RCRA regulations. RFFAs 1, 2, 9, and 10 apply to the NAA the same way they apply to the specific measures described above in Section 4.18.2.

The effects of the NAA would be a negligible contribution to the overall adverse cumulative effects to public health and safety from HTRW occurring in the WVS from applicable cumulative actions. Therefore, when considered in tandem with applicable cumulative actions, the NAA would create adverse, additive, and negligible cumulative effects to public health and safety from HTRW.

#### *4.18.3.2 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Alternative 1 would combine storage-focused measures in order to improve fish passage. As discussed above in Section 4.18.2, the effects of these measures would be negligible in magnitude, adverse, and local in extent in the short, medium, and long term.

Cumulative effects would be greater than Alternatives 2A, 2B, 3A, 3B, and 5, but less than Alternative 4. Any hazardous waste generated under Alternative 1 would represent a very small contribution to the overall cumulative effects compared to all cumulative actions within the WVS and WRB.

#### *4.18.3.3 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam)*

Alternative 2A would integrate water management flexibility and ESA-listed fish measures (using structural downstream passage at Cougar Dam). As discussed above in Section 4.18.2, the effects of these measures would be negligible in magnitude, adverse, and local in extent in the short, medium, and long term.

Cumulative effects would be greater than Alternatives 2B and 5, although not appreciably, and less than Alternatives 1, 3A, 3B, and 4. Any hazardous waste generated under Alternative 2A would represent a very small contribution to the overall cumulative effects compared to all cumulative actions within the WVS and WRB.

#### *4.18.3.4 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 2B would integrate water management flexibility and ESA-listed fish measures (using a deep drawdown to Cougar Dam's DT). As discussed above in Section 4.18.2, the effects of these measures would be negligible in magnitude, adverse, and local in extent in the short, medium, and long term.

Cumulative effects would be the same as Alternative 5 and less than all other action alternatives due to the number of construction projects that would have medium- and long-term effects. Any hazardous waste generated under Alternative 2B would represent a small contribution to the overall cumulative effects compared to all cumulative actions within the WVS and WRB.

#### *4.18.3.5 Alternative 3A – Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)*

Alternative 3A would improve fish passage by using operations-focused measures (using a deep drawdown to Cougars Dam's RO). As discussed above in Section 4.18.2, the effects of these measures would primarily be negligible in magnitude, adverse, and local in extent in the short, medium, and long term. Due to the deeper fall reservoir drawdown at Blue River, there would also be minor in magnitude, local in extent, adverse, and long-term recurring effects.

Cumulative effects would be greater than Alternatives 2A, 2B, and 5, but less than Alternatives 1, 3B, and 4. Any hazardous waste generated under Alternative 3A would represent a small contribution to the overall cumulative effects compared to all cumulative actions within the WVS and WRB.

#### *4.18.3.6 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)*

Alternative 3B would improve fish passage by using operations-focused measures (using a deep drawdown to Cougar Dam's DT). As discussed above in Section 4.18.2, the effects of these measures would primarily be negligible in magnitude, adverse, and local in extent in the short, medium, and long term. Due to the deeper fall reservoir drawdown at Blue River, there would also be minor in magnitude, local in extent, adverse, and long-term recurring effects.

Cumulative effects would be greater than Alternatives 2A, 2B, 3A, and 5, but less than Alternatives 1 and 4. Any hazardous waste generated under Alternative 3B would represent a small contribution to the overall cumulative effects compared to all cumulative actions within the WVS and WRB.

#### *4.18.3.7 Alternative 4 – Improve Fish Passage with Structures-Based Approach*

Alternative 4 would improve fish passage with structures-based measures. As discussed above in Section 4.18.2, the effects of these measures would be negligible in magnitude, adverse, and local in extent in the short, medium, and long term.

Cumulative effects would be greater than Alternatives 1, 2A, 2B, 3A, 3B, and 5. Any hazardous waste generated under Alternative 4 would represent a small contribution to the overall cumulative effects compared to all cumulative actions within the WVS and WRB; however, it would be a greater contribution than any of the other action alternatives.

#### ***4.18.3.8 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)***

Alternative 5 would only differ from Alternative 2B by way of the *refined* integrated temperature management and habitat flow regime measure (#30b), which is not a measure that would have effects on public health and safety from HTRW. Therefore, the effects of Alternative 5 would be identical to those of Alternative 2B: negligible in magnitude, and less than all other action alternatives because these alternatives include the fewest construction projects with medium- and long-term effects.

### 4.18.4 Summary

The cumulative effects under all alternatives would be adverse, additive, and minor to moderate from construction measures, especially those with long-term operational effects after initial construction, when considered in tandem with ongoing and present structural improvements, future population growth and accompanying urban, industrial, and commercial development, invasive species management, and mining operations. Alternatives 3A and 3B would have additional adverse, additive, and minor cumulative effects from recurring fall reservoir drawdown at Blue River when considered in tandem with climate change. Alternative 2B and 5 would have the least-severe adverse effects, followed by Alternatives 2A, 3A, 3B, 1, and 4.

## 4.19 PUBLIC HEALTH AND SAFETY - DRINKING WATER

This section discusses the cumulative effects on Public Health and Safety – Drinking Water. This includes a discussion of the effects of proposed measures considered alongside applicable cumulative actions, and how each project alternative would cumulatively affect public health and safety as related to drinking water. The geographic scope for public health and safety – drinking water would be the same boundary as described in the Affected Environment in Chapter 3, which includes the 13 dams, reservoirs, and downstream reaches within the WRB.

### 4.19.1 Cumulative Actions Applicable to Public Health and Safety – Drinking Water

Past, present, and reasonably foreseeable future actions that, when considered together with the Proposed Action and alternatives, would have cumulative effects from public health and safety – drinking water, include:

- Construction of the WVS dams, supporting structures, and non-USACE dams;
- Water quality management;
- Agricultural, urban and transportation corridor development;
- Water withdrawals for irrigation, municipal, and industrial uses to support human development in the Willamette Valley;
- Floodplain development;
- Dredging and sediment management;
- Point and non-point source water pollution;
- RFFA 1, future population growth and accompanying urban, industrial, and commercial development;
- RFFA 2, reduced agricultural production;
- RFFA 3, water withdrawals for municipal, industrial, and agricultural uses;
- RFFA 5, federal and state wildlife and lands management;
- RFFA 7, tribal, state, and local fish and wildlife improvement;
- RFFA 8, invasive species management;
- RFFA 9, climate change; and
- RFFA 10, mining operations.

Other RFFAs discussed in Section 4.1 would not have a cumulative effect on public health and safety – drinking water. These include RFFA 4, decarbonizing the energy sector with renewable energy sources; RFFA 6, fishery management and killer whales; and RFFA 11; timber and logging industry operations. These actions do not contribute to land development and the subsequent water pollution in the watershed that discharges to the reservoirs cumulatively lead to poor drinking water quality; thus, these RFFAs were dismissed from further analysis. RFFA 11 was dismissed from further analysis because timber and logging operations do not occur within the WRB.

### 4.19.2 Discussion of Cumulative Effects by Measure(s)

This section considers the proposed measures with relevant cumulative actions to determine the potential cumulative effects to public health and safety - Drinking water. The proposed measures analyzed in Section 3.19 and listed below would all contribute to the cumulative effects on public health and safety – Drinking water.

#### *4.19.2.1 Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration (#9), Continued Operation of Existing Adult Fish Facilities, Operation, Maintenance, Repair, Replacement, and Rehabilitation, Restore upstream and downstream passage at drop structures (#639), Construct adult fish facility (AFF) (#722), Provide Pacific lamprey passage and infrastructure (#52), and Construct structural downstream fish passage (#392)*

As discussed under Section 3.19.6.3, the effects of these measures are adverse and/ or beneficial, negligible and/or minor in magnitude, small in extent, in the short term, medium term, and long term. These effects are caused by either construction of the proposed measure or maintenance activities which would be mitigated by erosion and sediment controls at the construction or maintenance site, and/or would be required to meet water quality requirements for construction discharges or effluent from fish facilities.

The ongoing and present construction of the WVS dams would continue to have similar effects with the proposed measures. Construction measures would be mitigated similarly to the construction measures proposed for the above listed measures. Therefore, when considered in tandem with applicable cumulative actions, these measures would create additive, negligible to minor, cumulative effects from public health and safety – Drinking water.

#### *4.19.2.2 Foster Fish Ladder Temperature Improvement (#479), Construct water temperature control (WTC) towers (#105), Structural improvements to reduce total dissolved gas (#174), Use spillway for surface spill in summer (#721), Pass water over spillway in spring for fish passage (#714), Augment instream flows by using the inactive pool (#718), Augment instream flows by using the power pool (#304), Reduce minimum flows to Congressionally authorized minimum flow requirements (#723), Fall Creek drawdown, Deeper fall reservoir drawdowns for fish passage (#40), and Use regulating outlets (ROs) to discharge colder water during drawdown operations in fall and winter to reduce water temperatures below dams (#166)*

As discussed under Section 3.19.6.3, the effects of these measures are adverse and/ or beneficial, minor in magnitude, large in extent, and long term. These measures allow the continual flow and blending of water that would prevent degradation of water quality that occurs when water is stagnant resulting in beneficial effects. These measures also contribute to adverse minor, large, and long-term effects due to the release of excess nutrients downstream that could cause adversely impact drinking water quality downstream.

The ongoing and present construction of the WVS system and water quality management would continue to have similar effects with the proposed measures. Construction measures would be mitigated as discussed above in 3.19.6.3.1 and the ongoing and present water quality management measures proposed would also aid in improving water quality of drinking water.

The ongoing and present land development actions discussed would interact additively or synergistically with public health and safety – drinking water. Measures which include increased development in the watershed due to population growth, such as construction of the WVS dams and non-USACE dams; agricultural, urban and transportation corridor development; water withdrawals for irrigation, municipal, and industrial uses; development of the floodplain; and point and non-point source water pollution are all activities which can lead to stormwater pollution and excessive nutrients discharging into the environment. The nutrient-laden runoff from the developed land in the watershed collects in the reservoirs reduces water quality. Excess nutrients would lead to small changes in water quality or could lead to substantial changes in water quality that could be mitigated by treatment at the drinking water facility. The cumulative effects of land development actions in the watershed would be adverse and negligible to minor.

Invasive species management (RFFA 8) in the watershed would have negligible to minor cumulative effects due to the use of pesticides and herbicides which could contaminate runoff and discharge into the reservoirs.

Conversely, land management and restoration for fish and wildlife (RFFA 5 and 7), as well as water quality management in the watershed, would result in beneficial direct minor to moderate cumulative effects on water quality as the preservation of natural land would protect water resources by filtering out nutrients in the environment and thereby reducing polluted discharge of water to the reservoirs.

Dredging and sediment management would have direct beneficial minor to moderate effects as the sediment in the reservoir would trap nutrients. Thus, dredging sediment from the reservoirs would reduce nutrients in the reservoir which could improve water quality.

Climate change would contribute to adverse moderate to major cumulative effects due to changes in temperature, precipitation and stream baseflows as analyzed in Section 3.19.

Lastly, mining operations are required to meet water quality requirements for effluent and therefore would have negligible to minor adverse cumulative effects on public health and safety – drinking water.

Therefore, when considered in tandem with applicable cumulative actions, these measures would create additive, negligible to major, cumulative effects on public health and safety – drinking water.

#### *4.19.2.3 Integrated temperature and habitat flow regime (#30a) and Refined integrated temperature and habitat flow regime (#30b)*

As discussed under Section 3.19.6.3, the effects of these measures are beneficial, minor in magnitude, small in extent, and long term. These measures promote the continual flow and blending of water that would be beneficial for water quality. The beneficial effects associated with land management and restoration as well as dredging and sediment management would have additive beneficial effects for the reasons discussed in 4.20.2.2 to public health and safety – drinking water.

When considered in tandem with these measures, cumulative actions would have adverse and beneficial, additive, and negligible to major cumulative effects to public health and safety - drinking water in the WVS.

#### *4.19.2.4 Spring reservoir drawdown for downstream fish passage (#720)*

As discussed under Section 3.19.6.3, the effects of the spring drawdown are adverse, major, and large and long term. The spring drawdown has major effects on the availability of drinking water for public health and safety because the spring drawdowns do not maintain conservation storage for M&I water usage affecting the ability to refill system-wide storage.

When considered in tandem with this measure, cumulative actions would have adverse, additive, and negligible to major cumulative effects to public health and safety - drinking water in the WVS.

### 4.19.3 Discussion of Cumulative Effects by Alternative

This section considers the relevant cumulative actions by alternative to determine the potential cumulative effects to Public Health and Safety - Drinking Water.

#### *4.19.3.1 No Action Alternative*

The NAA aggregated with the cumulative effects of past, ongoing and future actions would cause additive adverse effects due to the land development activities in the watershed, invasives management, climate change, and mining operations and beneficial additive effects due to land management, restoration, water quality management, and dredging as discussed under Section 4.20.1 and 4.20.2. The additive effects would result in adverse and beneficial additive, negligible to major effects on drinking water and public health and safety. Spring drawdown

#### *4.19.3.2 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Under Alternative 1, fish passage would be approved through storage-focused measures by maximizing refill volumes of conservation pools and tapping into the power pool and augmenting flow to the congressionally authorized minimum flows. This would increase the likelihood of refilling to the maximum conservation pool levels as discussed under Section 2.4.3. The effects are similar to the NAA but still appreciably greater than the NAA because the reservoirs will be maximizing storage which can lead to greater nutrient accumulation in the reservoir which could reduce water quality. The aggregated effects on Alternative 1 would result in overall adverse additive, negligible to major cumulative effects.

#### *4.19.3.3 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Under Alternative 2A, integrated temperature and habitat flow regimes would be utilized as well as using the power pool to augment flows. Structural and operational measures are proposed to address water quality as well as the Near-Term Operations Measure as discussed under Section 2.2.5. These measures would have adverse and beneficial additive, negligible to major cumulative effects similar to Alternative 1 but would be appreciably less than the effects of Alternative 1 because it has a focus on maximizing storage which can lead to a higher accumulation of nutrients in the reservoirs and poor water quality.

#### *4.19.3.4 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Under Alternative 2B, the cumulative effects to public health and safety – drinking water would be the same as those described under Alternative 2A. The difference is that the downstream passage measure at Cougar Dam is changed from a structural fish passage structure (#392) under 2A to changing of operations to a deeper fall reservoir drawdown (#40) and spring reservoir drawdown (#720) with the construction of a diversion tunnel under 2B. These measures would contribute nearly identical adverse and beneficial, additive, negligible to major cumulative effects as Alternative 1 and 2A, however effects would be appreciably greater than 1 and 2A due to the major adverse impacts resulting from the spring reservoir drawdown for downstream fish passage (#720).

#### *4.19.3.5 Alternative 3A – Operations-Focused Fish Passage Alternative*

Under Alternative 3A, improved fish passage is proposed through the modifying of operations instead rather than focusing on storage (Alternative 1) or structural measures (Alternative 4). This alternative also includes the Near-Term Operations Measure. As discussed above in Sections 4.19.2, these measures would have adverse and beneficial, additive, negligible to major cumulative effects. Alternative 3A would have the same cumulative effect as Alternatives 1, 2A, and 2B, however effects would be nearly identical to 2B and appreciably greater than 1 and 2A due to the major adverse impacts resulting from the spring reservoir drawdown for downstream fish passage (#720).

#### *4.19.3.6 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)*

Under Alternative 3B, the cumulative effects to public health and safety – drinking water would be the same as those described under Alternative 3A. Alternative 3B proposes the slightly different combination of operations for the downstream passage. 3A proposes the drawdown to 10 feet over the top of the Cougar Dam RO for deep fall and spring drawdown measures and 3B includes drawdown utilizing the diversion tunnel at Cougar.

As discussed above in Sections 4.19.2, these measures would contribute adverse and beneficial additive, negligible to major cumulative effects. Alternative 3B would have the same cumulative effect as Alternative 1, 2A, 2B, and 3A, however effects would be overall less than Alternative 1. Alternative 3A would have the same cumulative effect as Alternatives 1, 2A, 2B, and 3A, however effects would be nearly identical to 2B and 3A and appreciably greater than 1 and 2A due to the major adverse impacts resulting from the spring reservoir drawdown for downstream fish passage (#720).

#### *4.19.3.7 Alternative 4 – Structures-Based Fish Passage Alternative*

Under Alternative 4, a structures-based approach is proposed to improve fish passage. The cumulative effects to public health and safety – drinking water would be the same as those described under Alternative 2A. Alternative 4 utilizes the integrated temperature and habitat flow regime proposed in Alternative 2A and includes Near Term Operations Measures as well as structural improvements.

As discussed above in Sections 4.19.2, these measures would contribute adverse and beneficial additive, negligible to major cumulative effects. Alternative 4 would have the same cumulative effect as Alternative 1, 2A, 2B, 3A, and 3B, however effects would be overall less than Alternatives 2B, 3A, and 3B because this alternative does not include the spring reservoir drawdown for downstream fish passage (#720).

#### *4.19.3.8 Alternative 5 – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Under Alternative 5 – the Preferred Alternative, fish passage would be improved through a combination of modified operations and structural improvements. Alternative 5 is exactly the same as Alternative 2B except the integrated temperature and habitat flow regime (measure #30a) is replaced with refined integrated temperature and habitat flow regime (measure #30b). As discussed above in Section 4.19.2, these measures would have adverse and beneficial additive, negligible to major cumulative effects. Alternative 5 would have the same cumulative effects as Alternative 1, 2A, 2B, 3A, 3B and 4, however effects would be overall less than Alternatives 2B, 3A, and 3B because this alternative does not include the spring reservoir drawdown for downstream fish passage (#720).

### 4.19.4 Summary

In summary, the cumulative effects of each of the alternatives would have similar additive, negligible, minor, moderate and major effects. Effects would be appreciably greater for Alternatives 2B, 3A and 3B due to the effects of spring reservoir drawdown for downstream fish passage (#720) on the availability of drinking water for public health and safety because the spring drawdowns do not maintain conservation storage for M&I water usage.

## 4.20 ENVIRONMENTAL JUSTICE

This section discusses the cumulative effects on environmental justice. This includes a discussion of the effects of proposed measures considered alongside applicable cumulative actions, and how each project alternative would cumulatively affect environmental justice. The geographic scope for environmental justice would be the same as described in the Affected Environment in Chapter 3, which is the following 10 counties:

- Benton County;
- Clackamas County;
- Columbia County;
- Lane County;
- Linn County;
- Marion County;
- Multnomah County;
- Polk County;
- Washington County; and
- Yamhill County.

Note that because this Draft PEIS discusses general, qualitative effects from construction at the programmatic level, the above-listed counties and specific Tribes were chosen as the ROI and the State of Oregon or the respective county as the ROC. Site-specific project details for each construction measure will be determined during the implementation phase. Subsequent tiered NEPA documents would discuss detailed site-specific effects and conduct the EJ analysis on a smaller scale, and use census tracts or census blocks to further identify pockets of minority, low-income, and Native American communities that could be disproportionately affected by the proposed construction measures.

### 4.20.1 Cumulative Actions Applicable to Environmental Justice

Past, present, and reasonably foreseeable future actions that, when considered together with the Proposed Action and alternatives, would have disproportionately high cumulative effects on environmental justice, include:

- Construction of the WVS and other dams and reservoirs in the WRB;
- Modifications of existing WVS structures at Dexter, Big Cliff, and Cougar;
- Transportation corridor development;
- RFFA 1, future population growth and accompanying urban, industrial, and commercial development;

- RFFA 3, water withdrawals for municipal, industrial, and agricultural uses;
- RFFA 5, federal and state wildlife and lands management;
- RFFA 6, fishery management and killer whales;
- RFFA 7, tribal, state, and local fish and wildlife improvement;
- RFFA 8, invasive species management;
- RFFA 9, climate change; and
- RFFA 10, mining operations.

Some of the other RFFAs discussed in Section 4.1.2.3 would not affect environmental justice within the ROI and hence are not considered in the cumulative effects analysis. These include RFFA 2, reduced agricultural production; RFFA 4, decarbonizing the energy sector with renewable energy sources; and RFFA 11, timber and logging industry operations. These actions would not appreciably affect the physical or environmental health and socioeconomic status of minority communities and would lead to no observable changes to Tribal subsistence and ceremonial fishing activities and recreation; they would not have disproportionately high effects on communities with EJ concerns. Therefore, these RFFAs are not discussed further in this analysis.

### 4.20.2 Discussion of Cumulative Effects by Measure(s)

This section considers the proposed measures with applicable cumulative actions to determine the potential cumulative effect to environmental justice. Where possible, the discussion of cumulative effects is grouped by measures that would have similar effects.

#### *4.20.2.1 Construction and/or Modification of Structural Measures*

This section discusses the potential cumulative effects to communities with EJ concerns from the construction and/or modification of the structural measures in combination with applicable cumulative actions. As discussed in Section 3.20.4.3.1, effects from construction and infrastructure modification/improvement activities would lead to short- and medium-term, negligible to minor socioeconomic benefits to minority communities due to creation of employment opportunities and the health benefits associated with employment. The long-term beneficial socioeconomic effects would be negligible.

There would also be negligible to minor adverse effects to the physical health and well-being of minority communities that are hired to work at the sites for the duration of these projects. During the post-construction lifetime of the project, noise, air emissions, and traffic from operation and maintenance activities would be minimal and therefore no long-term effects are anticipated.

Residential development on most of the shores of most of the WVS reservoirs is minimal, including at Big Cliff, Blue River, Cottage Grove, Cougar, Dorena, Fall Creek, Green Peter, Hills

Creek, and Lookout Point reservoirs. None of these reservoirs have towns on their shorelines. Detroit, Dexter, Fern Ridge, and Foster reservoirs have the towns of Detroit, Lowell, Veneta, and Sweet Home on their shores, respectively, which range from populations of 192 to 10,000. As discussed in Section 3.20.1, the town of Detroit is in Marion County (which was identified as having minority populations with EJ concerns), but the town of Detroit does not qualify as a population with EJ concerns (USCB, 2019s; USCB, 2019t). Lowell and Veneta are in Lane County and Sweet Home is in Linn County, so discussion of disproportionately high impacts from noise disturbances, air emissions, or traffic to these towns from construction measures will be included in a tiered EA or EIS if after using census tracts or census blocks, they are identified as having populations with EJ concerns.

Short- and medium-term negligible to minor effects to Tribal subsistence fishing activities and recreation would occur due to construction-related disturbances to fish species and restricted access to the affected reservoirs; as well as to the physical health of recreators due to increased air emissions. While the implementation of the above measures would not result in overall beneficial effects to Tribal subsistence and ceremonial fishing activities, the effects would be less adverse than those currently experienced by Tribes from dwindling fish populations in the WRB. These adverse effects would range from minor to major in the long term.

Modifications of existing WVS and other, non-USACE structures at Dexter, Big Cliff, and Cougar; transportation corridor development; RFFA 1, future population growth and accompanying urban, industrial, and commercial development; and RFFA 10, mining operations would have similar socioeconomic benefits and adverse health effects on minority populations hired to work on the construction of the proposed structural measures. As such, these additional projects would result in greater effects to communities with EJ concerns overall, compared to the effects described in Section 3.20.4.3.1, but not so great that the magnitude of a particular activity would increase. The cumulative effects to communities with EJ concerns from construction/modification of structural measures in combination with the above-mentioned cumulative actions are described below.

The direct and indirect cumulative socioeconomic effect on minority communities from job creation and the health benefits associated with jobs would be beneficial, additive, negligible to minor in magnitude, and occur in the short-term and medium-term. These long-term beneficial cumulative effects would be negligible in magnitude and additive. Adverse, additive, cumulative effects on the health of communities with EJ concerns hired to work at the project sites would occur in the short-term and medium-term and be negligible to minor in magnitude. Once construction of the projects is complete, no long-term adverse cumulative health effects to workers would occur. Beneficial socioeconomic effects and adverse health effects on communities with EJ concerns would be disproportionately high, but would not be significant.

Modifications of existing WVS structures and other non-USACE structures at Dexter, Big Cliff, and Cougar in combination with the proposed structural measures would have adverse cumulative effects to Tribal subsistence fishing activities and recreation at and near the affected reservoirs. More restricted access to these sites, disturbances to fish species from increased turbidity and suspended sediment transport during construction, and contamination of the harvest in the event of accidental fuel and chemical spills would occur. RFFA 9, climate change, could further exacerbate effects as increased wildfire ash, HABs, and erosion would further increase turbidity and could further reduce the quantity and quality of some fish species available for harvest. As such, the proposed structural measures in combination with modifications of existing WVS structures at Dexter, Big Cliff, and Cougar and climate change would have adverse, minor to moderate, additive, cumulative effects in the short and medium term. The implementation of the structural measures at Dexter, Big Cliff, and Cougar would not result in overall beneficial effects to Tribal subsistence and ceremonial fishing activities, but would generally contribute to decreasing the severity of effects of those that are currently experienced by Tribes due to dwindling fish populations in the WRB. As such, additive, cumulative effects to Tribal subsistence fishing would range from minor to moderate in the long term. These effects would be disproportionately high and adverse, but would not be significant.

#### *4.20.2.2 Implementation of Water Management Measures*

This section discusses the potential cumulative effects to communities with EJ concerns from the implementation of water management measures in combination with applicable cumulative actions.

Adverse economic effects associated with drawdowns are discussed at length throughout the socioeconomics section, beginning in Section 3.11.2.4.2 (Alteration of outflows and reservoir levels/Recreational Value), and is summarized briefly here as it applies to populations with EJ concerns. Drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. These short- and long-term recurring adverse effects would range from minor to major. The magnitude of effects under each alternative would depend on the number of drawdowns per year and the number of reservoirs at which they would occur. These effects would be adverse and disproportionate to populations with EJ concerns that are located in the county where drawdowns would occur or that are economically dependent on the reservoir where the drawdowns would occur. Disproportionately high and adverse effects that are major in magnitude would be considered a significant effect.

The Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Cow Creek Band of Umpqua Tribe of Indians, and Confederated Tribes of the Umatilla Indian Reservation are located in Yamhill, Jefferson and Wasco, Wasco, Lincoln, and Lincoln counties (respectively). Drawdowns are not proposed at any of the reservoirs located in the aforementioned counties. However, as noted above, while many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022). As such, drawdowns under all alternatives could adversely and disproportionately affect Tribal members throughout the WVS that are economically dependent on the reservoirs where drawdowns are proposed.

As discussed in 3.20.4.3.2, reservoir drawdowns would result in high rates of sediment transport from the reservoir and high turbidity levels in areas downstream; and cause minor adverse effects to Tribal subsistence fishing activities – in particular to Pacific lamprey – in the short-term and long-term recurring. While it is assumed that the majority of recreationists would forgo visiting the reservoir during drawdowns, those that continue to visit reservoirs during drawdowns would experience adverse and major effects because visually drawdowns would be very noticeable, and would substantially impact the recreational experience – including that of Tribal members. These effects would occur in the short term during the three-week drawdown and recur in the long term.

RFFA 1, future population growth and accompanying urban, industrial, and commercial development; RFFA 3, water withdrawals for municipal, industrial, and agricultural uses; and RFFA 9, climate change would have similar types of effects as or exacerbate effects from the proposed drawdowns and could adversely affect freshwater fish species due to the decrease in water quantity, increase in temperature, and degradation of water quality in streams and rivers throughout the WRB. The human population, which is expected to grow by 37 percent by 2050, would create further developmental pressures on riparian areas and floodplains, leading to their conversion to impervious areas, and generation of greater volumes of effluents and non-point source pollution that heats water bodies and affects water quality. The changing regional and global climate is expected to affect water bodies in the WRB by resulting in changes to the water temperatures, flow regime, hydrology and ecosystem processes, increased exposure of fish to diseases and parasites, and increase in the prevalence of invasive species, thereby leading to changes in population, habitat quality, and distribution of fisheries resources harvested by subsistence communities. Higher air and water temperatures, less water in river and reservoir systems, and more frequent and severe wildfires would decrease water quality from higher turbidity and increased occurrence of HABs (which would decrease dissolved oxygen (DO) concentrations and could adversely affect fish populations). The effects from RFFA 9, climate change would (in particular) affect the hatching, growth, migration, and survival of fish species in the WVS (Hixon et al. 2010). These cumulative actions would further disrupt subsistence harvest patterns by decreasing the fish species available for harvest, disrupting the seasonality of harvest activities and locations of fishing areas, and inducing stress within or between communities by adversely affecting subsistence resource sharing activities. RFFAs 1, 3, and 9, when considered in tandem with the proposed drawdowns would have additive, adverse, minor cumulative effects on Tribal subsistence fishing in the short term and recur in the long term. These effects to Tribal subsistence fishing would be disproportionately high and adverse, but would not be significant.

RFFAs 1, 3, and 9 would have similar types of visual effects as or exacerbate effects from the proposed drawdowns. RFFA 9 would cause longer and more arid drought seasons and smaller snowpacks, which affect reservoir storage capacity. If reservoir levels are already lower due to low summer flows and long-lasting droughts, RFFA 3 would exacerbate these low levels. Shoreline erosion from low reservoir levels could occur and cause sedimentation and increase turbidity, affecting water color and clarity; RFFA 1 would also contribute to sedimentation and increased turbidity with the conversion of riparian areas and floodplains to impervious surfaces (as discussed above). These cumulative actions would further affect the recreational experience of Tribal members. As such, RFFAs 1, 3, and 9, when considered in tandem with the proposed drawdowns would result in additive, adverse, major cumulative effects on all recreationists, including Tribal recreationists in the short term and recur in the long term. These disproportionately high and major, adverse effects would be considered significant.

RFFA 5, federal and state wildlife and lands management, RFFA 6, fishery management and killer whales, RFFA 7, tribal, state, and local fish and wildlife improvement, and RFFA 8, invasive species management would have benefits similar to those from the proposed water management measures and augment fish spawning and rearing habitat, improve instream water quality by ensuring instream temperature and TDG control, ensure adequate streamflow for biologically justified flows, and improve fish passage. For example, RFFA 6 and RFFA 7 improve habitat and ecosystem functions, as well as species-specific conservation. One recent project restored a stretch of the Willamette River and provided resting spots for salmon, wetland habitat for wildlife, and fertile floodplains for trees, shrubs, and other plants. As such, RFFAs 5, 6, 7, and 8 would offset some of the adverse effects from RFFAs 1, 3, and 9 described above. However, these RFFAs and the water management measures are not expected to lead to an increase in the availability of salmon, steelhead, or lamprey for Tribal subsistence and ceremonial purposes, but would further reduce the likelihood that the species would be in jeopardy of extinction. Overall, fishing activities would not be restored at traditional sites currently abandoned by the Tribes due to dwindling fish populations. Members of the Tribes would still need to spend as much time and money as they presently do in order to travel to distant fishing sites to secure sufficient quantities of harvest. This would not help ease conflict between competing Tribes that are forced to share specific fishing sites; however, the continued existence of these fish species in the WRB would support the preservation of their cultural practices and pass on their knowledge of traditional fishing methods and customs to their youth. RFFAs 5, 6, 7, and 8 and the implementation of water management measures would not provide adequate food reserves for meetings, celebrations, and subsistence; Tribes would continue to rely on hatchery fish from ODFW facilities. While the implementation of water management measures as well as RFFAs 5, 6, 7, and 8 would not result in overall beneficial effects to Tribal subsistence and ceremonial fishing activities, the effects would be less adverse than those currently experienced by Tribes due to dwindling fish populations in the WRB. As such, cumulative, adverse effects would be additive, minor to moderate in magnitude, and long-term in duration. These effects to Tribal subsistence fishing would be disproportionately high and adverse, but would not be significant.

### *4.20.3* Discussion of Cumulative Effects by Alternative

This section analyzes the relevant cumulative actions by alternative to determine the potential cumulative effects to environmental justice.

#### *4.20.3.1 No Action Alternative*

Under the NAA, the current operating conditions of the WVS would continue, including major maintenance and rehabilitation projects and the annual Fall Creek reservoir drawdown. As described above in Section 4.20.2.1, when considered in tandem with cumulative actions that would create jobs (the modifications of existing WVS structures and non-USACE structures at Dexter, Big Cliff, and Cougar; transportation corridor development; and RFFA 10, mining operations), major maintenance and rehabilitation projects would create negligible, beneficial, additive, cumulative effects to the socioeconomic conditions of minority communities in the ROI in the short, medium, and long term. The adverse, additive cumulative effects from air quality, noise levels, viewshed, and traffic and transportation conditions to the physical health and well-being of communities with EJ concerns hired to work at the project sites and communities residing in the vicinity of the project locations would be negligible to minor. Beneficial socioeconomic effects and adverse health effects on communities with EJ concerns would be disproportionately high, but would not be significant.

As discussed above in 4.20.2.1, modifications of existing WVS structures at Dexter, Big Cliff, and Cougar could further restrict access to subsistence fishing and recreation activities, disturb fish species from increased turbidity and suspended sediment transport during construction, and contaminate the harvest if accidental fuel and chemical spills occur. As such, modifications of existing WVS structures at Dexter, Big, Cliff and Cougar and any major maintenance and rehabilitation projects at these locations would have minor and additive cumulative adverse effects to Tribal subsistence fishing and recreation in the short and medium term. Additive, cumulative, adverse effects to Tribal subsistence fishing would be major in the long term because measures under the NAA and the modifications of existing WVS structures would continue to not adequately benefit the fish species essential to meet the subsistence and ceremonial requirements of the Tribes in the ROI. These effects are the most adverse and severe in magnitude compared to the other action alternatives. These effects would be disproportionately high and adverse, but would not be significant.

Drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. The Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Cow Creek Band of Umpqua Tribe of Indians, and Confederated Tribes of the Umatilla Indian Reservation are not located in Lane County, where the Fall Creek Drawdown occurs. However, while many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022). As such, drawdowns could adversely and disproportionately affect Tribal members throughout the WVS that are economically dependent on the Fall Creek Reservoir. Given that one drawdown would occur annually in one county, the magnitude of effects would be minor and extent of the extent would likely be medium under this alternative, occurring in some of the counties in the WVS. These effects would be disproportionately high and adverse, but would not be significant.

As discussed above in 4.20.2.2, RFFAs 1, 3, and 9 would have similar types of visual effects as or exacerbate effects from the Fall Creek Drawdown as increased wildfire ash, HABs, and erosion would further increase turbidity and could further reduce the quantity and quality of some fish species available for harvest. RFFAs 1, 3, and 9, when considered in tandem with the Fall Creek drawdown would have additive, adverse, minor cumulative effects on Tribal subsistence fishing in the short term and recur in the long term. RFFAs 1, 3, and 9, in combination with the Fall Creek drawdown would result in additive, adverse, major cumulative effects on all recreationists, including Tribal recreationists, because visually even lower water levels and even more turbidity would be very noticeable and would substantially impact the recreational experience. These effects would occur in the short term and recur in the long term. These disproportionately high and major, adverse effects to recreation would be considered significant.

#### *4.20.3.2 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Alternative 1 consists of structural improvements and water management measures which maximize refill volumes of conservation pools at WVS reservoirs in support of improved survival of ESA-listed fish species in addition to other authorized project purposes of the structures. As discussed above in Sections 4.20.2.1, when the proposed structural measures are considered in tandem with the other cumulative actions that would create jobs (i.e., modifications of existing WVS structures and non-USACE structures at Dexter, Big Cliff, and Cougar; transportation corridor development; RFFA 1; and RFFA 10), the cumulative socioeconomic benefit on minority communities would be additive and minor in magnitude in the short and medium term and negligible in the long term. Adverse cumulative effects of construction and infrastructure improvement activities on the health of minority construction workers hired to work at the project sites and neighboring EJ communities would be additive and minor in magnitude, and would be short- to medium- term in duration. No long-term adverse cumulative health effects to workers would occur once construction is complete. Beneficial socioeconomic effects and adverse health effects on communities with EJ concerns would be disproportionately high, but would not be significant.

As discussed above in 4.20.2.1, modifications of existing WVS structures at Dexter, Big Cliff, and Cougar could further restrict access to subsistence fishing and recreation activities, disturb fish species from increased turbidity and suspended sediment transport during construction, and contaminate the harvest if accidental fuel and chemical spills occur. As such, structural measures under Alternative 1 and modifications of existing WVS structures at Dexter, Big Cliff, and Cougar would have minor to moderate and additive cumulative, adverse effects to Tribal subsistence fishing and recreation in the short and medium term. Additive, cumulative effects to Tribal subsistence fishing would be minor to moderate in the long term under Alternative 1. No long-term effects would occur to recreation. These effects would be disproportionately high and adverse, but would not be significant.

Drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. The Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Cow Creek Band of Umpqua Tribe of Indians, and Confederated Tribes of the Umatilla Indian Reservation are not located in Lane County, where the Fall Creek Drawdown occurs. While many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022). As such, drawdowns could adversely and disproportionately affect Tribal members throughout the WVS that are economically dependent on the Fall Creek Reservoir. Given that one drawdown would occur annually in one county, the magnitude of effects would be minor and the extent would likely be medium under this alternative, occurring in some of the counties in the WVS. These effects would be disproportionately high and adverse, but would not be significant.

As discussed above in 4.20.2.2, RFFAs 1, 3, and 9 would have similar types of visual effects as or exacerbate effects from the Fall Creek Drawdown as increased wildfire ash, HABs, and erosion would further increase turbidity and could further reduce the quantity and quality of some fish species available for harvest. As such, cumulative effects on Tribal subsistence fishing would be additive, adverse, and minor in the short term and recur in the long term. These effects would be disproportionately high and adverse, but would not be significant.

When the Fall Creek drawdown is considered in tandem with RFFAs 1, 3, and 9, cumulative effects to recreation would be major, adverse, additive, and would occur in the short term and recur in the long term. These disproportionately high and major, adverse effects would be considered significant.

As described above, while the implementation of the proposed measures and the cumulative actions would not result in overall beneficial effects to Tribal subsistence and ceremonial fishing activities, effects would be less adverse than those that are currently experienced by Tribes due to dwindling fish populations in the WRB. Though beneficial effects from the effective implementation of RFFAs 5, 6, 7, and 8 could offset some of the adverse effects from RFFAs 1, 3, and 9, these are not expected to change the severity of adverse effects. Overall, long-term adverse cumulative effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would be moderate in magnitude and would be additive. These impacts would be disproportionately high and adverse but would not be considered significant.

#### *4.20.3.3 Alternative 2a – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam)*

Alternative 2a aims to improve fish passage through the WVS dams using a combination of modified operations and structural improvements, along with other measures to manage water management flexibility and meet ESA-listed fish obligations. As discussed above in Section 4.20.2.1, when the proposed structural measures are considered in tandem with cumulative actions with construction phases that would create jobs (i.e., modifications of existing WVS structures and non-USACE structures at Dexter, Big Cliff, and Cougar; transportation corridor development; RFFA 1; and RFFA 10), the cumulative socioeconomic effects of Alternative 2a on minority communities would be beneficial, additive, and minor in magnitude in the short and medium term and negligible and beneficial in the long term. Adverse cumulative effects of construction and infrastructure improvement activities on the health of minority construction workers hired to work at the project sites and neighboring communities with EJ concerns would be additive and minor in magnitude, and would be short- to medium- term in duration. No long-term adverse cumulative health effects to workers would occur once construction is complete. Beneficial socioeconomic effects and adverse health effects on communities with EJ concerns would be disproportionately high, but would not be significant.

As discussed above in 4.20.2.1, modifications of existing WVS structures and non-USACE structures at Dexter, Big Cliff, and Cougar could further restrict access to subsistence fishing and recreation activities, disturb fish species from increased turbidity and suspended sediment transport during construction, and contaminate the harvest if accidental fuel and chemical spills occur. As such, structural measures under Alternative 2a and modifications of existing WVS structures at Dexter, Big Cliff, and Cougar would have minor to moderate and additive, cumulative adverse effects to Tribal subsistence fishing and recreation in the short and medium term. Additive, cumulative effects to Tribal subsistence fishing would be minor to moderate in the long term under Alternative 2a. No long-term effects would occur to recreation. These effects would be disproportionately high and adverse, but would not be significant.

Drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. The Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Cow Creek Band of Umpqua Tribe of Indians, and Confederated Tribes of the Umatilla Indian Reservation are not located in Lane and Linn counties, where the Fall Creek and Green Peter reservoirs (respectively) are located; and where annual drawdowns are proposed. While many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022) and may be impacted by annual drawdowns at Fall Creek and Green Peter reservoirs. As such, drawdowns could adversely and disproportionately affect Tribal members throughout the WVS that are economically dependent on the Fall Creek and Green Peter reservoirs. Given that two annual drawdowns would occur at two reservoirs, the magnitude of effects would be minor and the extent would likely be medium under this alternative, occurring in some of the counties in the WVS. These effects would be disproportionately high and adverse, but would not be significant.

As discussed above in 4.20.2.2, RFFAs 1, 3, and 9 would have similar types of visual effects as or exacerbate effects from the Fall Creek and Green Peter drawdowns as increased wildfire ash, HABs, and erosion would further increase turbidity and could further reduce the quantity and quality of some fish species available for harvest. When the Green Peter and Fall Creek drawdowns are considered in tandem with RFFAs 1, 3, and 9, cumulative, additive, and adverse effects would be major on Tribal recreation and minor on Tribal subsistence fishing activities; and would occur in the short term and recur in the long term. Overall impacts to Tribes would be disproportionately high and adverse. Impacts to subsistence fishing would not be considered significant but impacts to recreation would be significant.

As described above, while the implementation of the proposed measures and the cumulative actions would not result in overall beneficial effects to Tribal subsistence and ceremonial fishing activities, effects would be less adverse than those that are currently experienced by Tribes due to dwindling fish populations in the WRB. Though beneficial effects from the effective implementation of RFFAs 5, 6, 7, and 8 could offset some of the adverse effects from RFFAs 1, 3, and 9, these are not expected to change the severity of adverse effects. Overall, long-term adverse cumulative effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would be moderate in magnitude and would be additive. These impacts would be disproportionately high and adverse but would not be considered significant.

#### *4.20.3.4 Alternative 2b – Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 2b is similar to Alternative 2a but proposes a slightly different combination of measures at Cougar Dam that are lower in construction expenditures than Alternative 2a. Given their overall similarity, the EJ effects of the measures under Alternative 2b are very similar to Alternative 2a and are affected by the same mechanisms discussed in Section 3.20.4.6.

As discussed above in Section 4.20.2.1, when the proposed structural measures are considered in tandem with the other cumulative actions that would create jobs (i.e., modifications of existing WVS structures and non-USACE structures at Dexter, Big Cliff, and Cougar; transportation corridor development; RFFA 1; and RFFA 10), the cumulative socioeconomic benefits of Alternative 2b on minority communities would be additive and minor in magnitude in the short and medium term and negligible in the long term. Adverse cumulative effects of construction and infrastructure improvement activities on the health of minority construction workers hired to work at the project sites and neighboring communities with EJ concerns would be additive and minor in magnitude, and would be short- to medium- term in duration. Beneficial socioeconomic effects and adverse health effects on communities with EJ concerns would be disproportionately high, but would not be significant.

Modifications of existing WVS structures at Dexter, Big Cliff, and Cougar could further restrict access to subsistence fishing and recreation activities, disturb fish species from increased turbidity and suspended sediment transport during construction, and contaminate the harvest if accidental fuel and chemical spills occur. As such, structural measures under Alternative 2b and modifications of existing WVS structures at Dexter, Big Cliff, and Cougar would have minor to moderate and additive, cumulative adverse effects to Tribal subsistence fishing and recreation in the short and medium term. Additive, cumulative effects to Tribal subsistence fishing would be minor to moderate in the long term under Alternative 2b. No long-term effects would occur to recreation. These effects would be disproportionately high and adverse, but would not be significant.

Drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. The Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Cow Creek Band of Umpqua Tribe of Indians, and Confederated Tribes of the Umatilla Indian Reservation are not located in Lane and Linn counties, where the Fall Creek, Green Peter, and Cougar reservoirs are located – and where annual drawdowns are proposed. While many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022) and may be impacted by annual drawdowns at Fall Creek, Green Peter, and Cougar reservoirs. As such, drawdowns could adversely and disproportionately affect Tribal members throughout the WVS that are economically dependent on the Fall Creek, Green Peter, and Cougar reservoirs. Given that three annual drawdowns would occur at three reservoirs, the magnitude of effects would be moderate and the extent would likely be medium under this alternative, occurring in some of the counties in the WVS. These effects would be disproportionately high and adverse, but would not be significant.

As discussed above in 4.20.2.2, RFFAs 1, 3, and 9 would have similar types of visual effects as or exacerbate effects from the Fall Creek, Cougar, and Green Peter drawdowns as increased wildfire ash, HABs, and erosion would further increase turbidity and could further reduce the quantity and quality of some fish species available for harvest. Drawdown-related impacts would be slightly greater for Alternative 2b compared to Alternative 2a due to an additional drawdown at Cougar, but overall cumulative effects would be the same. When the Cougar, Green Peter, and Fall Creek drawdowns are considered in tandem with RFFAs 1, 3, and 9, cumulative, additive, and adverse effects would be major on Tribal recreation and minor on Tribal subsistence fishing activities; and would occur in the short term and recur in the long term. Overall impacts to Tribes would be disproportionately high and adverse. Impacts to subsistence fishing would not be considered significant but impacts to recreation would be significant.

As described above, while the implementation of the proposed measures and the cumulative actions would not result in overall beneficial effects to Tribal subsistence and ceremonial fishing activities, effects would be less adverse than those that are currently experienced by Tribes due to dwindling fish populations in the WRB. Though beneficial effects from the effective implementation of RFFAs 5, 6, 7, and 8 could offset some of the adverse effects from RFFAs 1, 3, and 9, these are not expected to change the severity of adverse effects. Overall, long-term adverse cumulative effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would be moderate in magnitude and would be additive. These impacts would be disproportionately high and adverse but would not be considered significant.

#### *4.20.3.5 Alternative 3a – Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)*

Alternative 3a focuses on modifying operations rather than storage or structural measures to improve the survival of ESA-listed fish species. As discussed above in Sections 4.20.2.1, when the proposed structural measures (comparatively fewer, especially when compared to Alternatives 1 and 4) are considered in tandem with the other cumulative actions that would create jobs (i.e., modifications of existing WVS structures and non-USACE structures at Dexter, Big Cliff, and Cougar; transportation corridor development; RFFA 1; and RFFA 10, mining operations), the cumulative socioeconomic benefits of Alternative 3a on minority communities would be additive and negligible in the short, medium, and long term. Adverse cumulative effects of construction and infrastructure improvement activities on the health of neighboring communities with EJ concerns would be additive and negligible in magnitude. Beneficial socioeconomic effects and adverse health effects on communities with EJ concerns would be disproportionately high, but would not be significant.

As discussed in 4.20.2.1, modifications of existing WVS structures at Dexter, Big Cliff, and Cougar could further restrict access to subsistence fishing and recreation activities, disturb fish species from increased turbidity and suspended sediment transport during construction, and contaminate the harvest if accidental fuel and chemical spills occur. As such, structural measures under Alternative 3a and modifications of existing WVS structures at Dexter, Big Cliff, and Cougar would have minor and additive effects on Tribal subsistence fishing and recreation in the short and medium term. Additive, cumulative effects to Tribal subsistence fishing would be minor in the long term under Alternative 3a. No long-term effects would occur to recreation. These effects would be disproportionately high and adverse, but would not be significant.

Drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. Minority populations with EJ concerns in Marion County could experience disproportionate and adverse effects associated with the fall and spring drawdowns at Detroit Reservoir. The Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Cow Creek Band of Umpqua Tribe of Indians, and Confederated Tribes of the Umatilla Indian Reservation are located in Yamhill, Jefferson and Wasco, Wasco, Lincoln, and Lincoln counties (respectively). Drawdowns are not proposed at any of the reservoirs located in the aforementioned counties. While many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022). As such, drawdowns could adversely and disproportionately affect Tribal members throughout the WVS that are economically dependent on the seven reservoirs where drawdowns are proposed, though drawdowns would not occur at any of the reservoirs located in counties encompassing Tribal reservations. Given that a total of ten drawdowns would occur at seven reservoirs, the magnitude of effects would be major and the extent would likely be large under this alternative, occurring in all the counties in the WVS. These disproportionately high and major, adverse effects would be considered significant.

As discussed above in 4.20.2.2, RFFAs 1, 3, and 9 would have similar types of visual effects as or exacerbate effects from drawdowns as increased wildfire ash, HABs, and erosion would further increase turbidity and could further reduce the quantity and quality of some fish species available for harvest. Drawdown-related impacts would be greatest under Alternative 3a (and 3b, discussed below) compared to the other alternatives due to the ten drawdowns across seven reservoirs. When the ten drawdowns are considered in tandem with RFFAs 1, 3, and 9, cumulative, additive, and adverse effects would be major on Tribal recreation and minor on Tribal subsistence fishing activities; and short-term and long-term recurring. Overall impacts to

Tribes would be disproportionately high and adverse. Impacts to subsistence fishing would not be considered significant but impacts to recreation would be significant.

As described above, while the implementation of the proposed measures and the cumulative actions would not result in overall beneficial effects to Tribal subsistence and ceremonial fishing activities, effects would be less adverse than those that are currently experienced by Tribes due to dwindling fish populations in the WRB. Adverse, cumulative effects under Alternative 3a (and Alternative 3b, discussed below) would be the least severe in the long term due to the number of drawdowns and the associated benefits to ESA-listed fish. Though beneficial effects from the effective implementation of RFFAs 5, 6, 7, and 8 could offset some of the adverse effects from RFFAs 1, 3, and 9, these are not expected to change the severity of adverse effects. Overall, long-term adverse cumulative effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would be minor in magnitude and would be additive. These effects would be disproportionately high and adverse, but would not be significant.

#### *4.20.3.6 Alternative 3b – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)*

Alternative 3b is similar to Alternative 3a but differs primarily in the downstream passage measures. Given their overall similarity, the EJ impacts of the measures under Alternative 3b are very similar to Alternative 3a and are affected by the same mechanisms discussed in Section 3.20.2.3.

As discussed above in Sections 4.20.2.1, when the proposed structural measures (similar to 3a but comparatively fewer, especially when compared to Alternatives 1 and 4) are considered in tandem with the other cumulative actions that would create jobs (i.e., modifications of existing WVS structures and non-USACE structures at Dexter, Big Cliff, and Cougar; transportation corridor development; RFFA 1; and RFFA 10, the cumulative socioeconomic benefits on minority communities would be additive and negligible in the short, medium, and long term. Adverse cumulative effects of construction and infrastructure improvement activities on the health of neighboring communities with EJ concerns would be additive and negligible in magnitude. Beneficial socioeconomic effects and adverse health effects on communities with EJ concerns would be disproportionately high, but would not be significant.

As discussed in 4.20.2.1, modifications of existing WVS structures at Dexter, Big Cliff, and Cougar could further restrict access to subsistence fishing and recreation activities, disturb fish species from increased turbidity and suspended sediment transport during construction, and contaminate the harvest if accidental fuel and chemical spills occur. As such, structural measures under Alternative 3b and modifications of existing WVS structures at Dexter, Big Cliff, and Cougar would have minor and additive effects on Tribal subsistence fishing and recreation in the short and medium term. Additive, cumulative effects to Tribal subsistence fishing would be minor in the long term under Alternative 3b. No long-term effects would occur to recreation. These effects would be disproportionately high and adverse, but would not be significant.

Drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. Minority populations with EJ concerns in Marion County could experience disproportionate and adverse effects associated with the fall and spring drawdowns at Detroit Reservoir. Drawdowns are not proposed at any of the reservoirs located in the counties where Tribal reservations occur (Yamhill, Jefferson, Wasco, and Lincoln counties); however, while many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022). As such, drawdowns could adversely and disproportionately affect Tribal members throughout the WVS that are economically dependent on the seven reservoirs where drawdowns are proposed. Given that a total of ten drawdowns would occur at seven reservoirs, the magnitude of effects would be major and the extent would likely be large under this alternative, occurring in all the counties in the WVS. These disproportionately high and major, adverse effects would be considered significant.

As discussed above in 4.20.2.2, RFFAs 1, 3, and 9 would have similar types of visual effects as or exacerbate effects from drawdowns as increased wildfire ash, HABs, and erosion would further increase turbidity and could further reduce the quantity and quality of some fish species available for harvest. Drawdown-related impacts would be greatest under Alternative 3b (and 3a, discussed above) compared to the other alternatives due to the ten drawdowns across seven reservoirs. When the ten drawdowns are considered in tandem with RFFAs 1, 3, and 9, cumulative, additive, and adverse effects would be major on Tribal recreation and minor on Tribal subsistence fishing activities; and short-term and long-term recurring. Overall impacts to Tribes would be disproportionately high and adverse. Impacts to subsistence fishing would not be considered significant but impacts to recreation would be significant.

As described above, while the implementation of the proposed measures and the cumulative actions would not result in overall beneficial effects to Tribal subsistence and ceremonial fishing activities, effects would be less adverse than those that are currently experienced by Tribes due to dwindling fish populations in the WRB. Adverse, cumulative effects under Alternative 3b (and Alternative 3a, discussed above) would be the least severe in the long term due to the number of drawdowns and the associated benefits to ESA-listed fish. Though beneficial effects from the effective implementation of RFFAs 5, 6, 7, and 8 could offset some of the adverse effects from RFFAs 1, 3, and 9, these are not expected to change the severity of adverse effects. Overall, long-term adverse cumulative effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would be minor in magnitude and would be additive. These effects would be disproportionately high and adverse, but would not be significant.

#### *4.20.3.7 Alternative 4 – Improve Fish Passage with Structures-Based Approach*

Alternative 4 consists almost entirely of structural improvements which increase stream flows and enhance fish passage in support of improved survival of ESA-listed fish species, and is very similar to Alternative 1. As discussed above in Sections 4.20.2.1, when the proposed structural measures are considered in tandem with the other cumulative actions that would create jobs (i.e., modifications of existing WVS structures and non-USACE structures at Dexter, Big Cliff, and Cougar; transportation corridor development; RFFA 1; and RFFA 10), the cumulative socioeconomic benefit of Alternative 4 on minority communities would be additive and minor in magnitude in the short and medium term and negligible in the long term. Adverse cumulative effects of construction and infrastructure improvement activities on the health of minority construction workers hired to work at the project sites and neighboring communities with EJ concerns would be additive and minor in magnitude, and would be short- and medium-term in duration. No long-term adverse cumulative health effects to workers would occur once construction is complete. Beneficial socioeconomic effects and adverse health effects on communities with EJ concerns would be disproportionately high, but would not be significant.

As discussed above in 4.20.2.1, modifications of existing WVS structures at Dexter, Big Cliff, and Cougar could further restrict access to subsistence fishing and recreation activities, disturb fish species from increased turbidity and suspended sediment transport during construction, and contaminate the harvest if accidental fuel and chemical spills occur. As such, structural measures under Alternative 4 and modifications of existing WVS structures at Dexter, Big Cliff, and Cougar would have minor to moderate and additive cumulative, adverse effects to Tribal subsistence fishing and recreation in the short and medium term. Additive, cumulative effects to Tribal subsistence fishing would be minor to moderate in the long term under Alternative 1. No long-term effects would occur to recreation. These effects would be disproportionately high and adverse, but would not be significant.

Drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. The Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Cow Creek Band of Umpqua Tribe of Indians, and Confederated Tribes of the Umatilla Indian Reservation are not located in Lane County, where the Fall Creek Drawdown occurs. While many or most Tribal members may live on, for example, the Grand Ronde Reservation, members also live across the communities in and around the WVS (Grand Ronde, 2022). As such, drawdowns could adversely and disproportionately affect Tribal members throughout the WVS that are economically dependent on the Fall Creek Reservoir. Given that one drawdown would occur annually in one county, the magnitude of effects would be minor and the extent would likely be medium under this alternative, occurring in some of the counties in the WVS. These effects would be disproportionately high and adverse, but would not be significant.

As discussed above in 4.20.2.2, RFFAs 1, 3, and 9 would have similar types of visual effects as or exacerbate effects from the Fall Creek Drawdown as increased wildfire ash, HABs, and erosion would further increase turbidity and could further reduce the quantity and quality of some fish species available for harvest. As such, cumulative effects on Tribal subsistence fishing would be additive, adverse, and minor in the short term and recur in the long term. When the Fall Creek drawdown is considered in tandem with RFFAs 1, 3, and 9, cumulative effects to recreation would be major, adverse, additive, and would occur in the short term and recur in the long term. Overall impacts to Tribes would be disproportionately high and adverse. Impacts to subsistence fishing would not be considered significant but impacts to recreation would be significant.

As described above, while the implementation of the proposed measures and cumulative actions would not result in overall beneficial effects to Tribal subsistence and ceremonial fishing activities, effects would be less adverse than those that are currently experienced by Tribes due to dwindling fish populations in the WRB. Though beneficial effects from the effective implementation of RFFAs 5, 6, 7, and 8 could offset some of the adverse effects from RFFAs 1, 3, and 9, these are not expected to change the severity of adverse effects. Overall, long-term adverse cumulative effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would be moderate in magnitude and would be additive. These effects would be disproportionately high and adverse, but would not be significant.

#### *4.20.3.8 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 5 would only differ from Alternative 2b by way of the refined integrated temperature management and habitat flow regime measure (#30b), which is not a measure that would have effects on environmental justice. Therefore, the effects of Alternative 5 would be identical to those of Alternative 2b.

As discussed above in Sections 4.20.2.1, when the proposed structural measures are considered in tandem with the other cumulative actions that would create jobs (i.e., modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; RFFA 1; and RFFA 10), the cumulative socioeconomic benefits of Alternative 5 on minority communities would be additive and minor in magnitude in the short and medium term and negligible in the long term. Adverse cumulative effects of construction and infrastructure improvement activities on the health of minority construction workers hired to work at the project sites and neighboring communities with EJ concerns would be additive and minor in magnitude, and would be short- to medium- term in duration. Beneficial socioeconomic effects and adverse health effects on communities with EJ concerns would be disproportionately high, but would not be significant.

As discussed in 4.20.2.1, modifications of existing WVS structures at Dexter, Big Cliff, and Cougar could further restrict access to subsistence fishing and recreation activities, disturb fish species from increased turbidity and suspended sediment transport during construction, and contaminate the harvest if accidental fuel and chemical spills occur. As such, structural measures under Alternative 5 and modifications of existing WVS structures at Dexter, Big Cliff, and Cougar would have minor to moderate and additive, cumulative adverse effects to Tribal subsistence fishing and recreation in the short and medium term. Additive, cumulative effects to Tribal subsistence fishing would be minor to moderate in the long term under Alternative 5. No long-term effects would occur to recreation. These effects would be disproportionately high and adverse, but would not be significant.

Drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. The Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Warm Springs, Confederated Tribes of Siletz Indians, Cow Creek Band of Umpqua Tribe of Indians, and Confederated Tribes of the Umatilla Indian Reservation are not located in Lane and Linn counties, where the Fall Creek, Green Peter, and Cougar reservoirs are located – and where annual drawdowns are proposed. As such, drawdowns could adversely and disproportionately affect Tribal members throughout the WVS that are economically dependent on the Fall Creek, Green Peter, and Cougar reservoirs. Given that three annual drawdowns would occur at three reservoirs, the magnitude of effects would be moderate and the extent would likely be medium under this alternative, occurring in some of the counties in the WVS. These effects would be disproportionately high and adverse, but would not be significant.

As discussed above in 4.20.2.2, RFFAs 1, 3, and 9 would have similar types of visual effects as or exacerbate effects from the Fall Creek, Cougar, and Green Peter drawdowns as increased wildfire ash, HABs, and erosion would further increase turbidity and could further reduce the quantity and quality of some fish species available for harvest. When the Cougar, Green Peter, and Fall Creek drawdowns are considered in tandem with RFFAs 1, 3, and 9, cumulative, additive, and adverse effects would be major on Tribal recreation and minor on Tribal subsistence fishing activities; and would occur in the short term and recur in the long term. Overall impacts to Tribes would be disproportionately high and adverse. Impacts to subsistence fishing would not be considered significant but impacts to recreation would be significant.

As described above, while the implementation of the proposed measures would not result in overall beneficial effects to Tribal subsistence and ceremonial fishing activities, effects would be less adverse than those that are currently experienced by Tribes due to dwindling fish populations in the WRB. Though beneficial effects from the effective implementation of RFFAs 5, 6, 7, and 8 could offset some of the adverse effects from RFFAs 1, 3, and 9, these are not expected to change the severity of adverse effects. Overall, long-term adverse cumulative effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would be moderate in magnitude and would be additive. These effects would be disproportionately high and adverse, but would not be significant.

### *4.20.4* Summary

The cumulative actions that would create jobs during construction phases (i.e., modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; transportation corridor development; RFFA 1; and RFFA 10) would have similar adverse and beneficial socioeconomic and health effects on communities with EJ concerns, including Tribes as the proposed structural measures. Cumulative effects would range from negligible to minor in the short and medium-term and be most severe for Alternatives 1 and 4, and least severe for Alternatives 3a and 3b since the greatest number of construction/structural measures would be implemented under Alternatives 1 and 4. Beneficial socioeconomic effects and adverse health effects on communities with EJ concerns, including Tribes, would be disproportionately high, but would not be significant.

RFFAs 1, 3, and 9 would have similar types of visual effects as or exacerbate effects from the drawdowns as increased wildfire ash, HABs, and erosion would further increase turbidity and could further reduce the quantity and quality of some fish species available for harvest. Cumulative effects from the implementation of water management measures, in particular reservoir drawdowns, in combination with RFFAs 1, 3, and 9 would be most severe for Alternatives 3a and 3b, followed by Alternative 2a, 2b, and5, and least severe for Alternatives 1 and 4. Major and adverse cumulative effects to Tribal recreation would occur under all alternatives in the short-term and recur in the long-term because visually lower water levels and increased turbidity would be very noticeable, and would substantially impact the recreational experience.

Drawdowns could result in the closure of water-based recreational businesses such as boat rental firms or guide services and ultimately reduce employment and consumer demand within the ROI. As such, drawdowns could adversely and disproportionately affect minority communities and Tribal members throughout the WVS that are economically dependent on the impacted reservoirs. Ten annual drawdowns would occur at seven reservoirs for alternatives 3a and 3b and as such, the magnitude of effects would be major and the extent would likely be large these two alternatives, occurring in all the counties in the WVS. These effects would be disproportionately high and adverse, and would be considered significant for these two alternatives. For all other alternatives, impacts from drawdowns would be less pronounced and would not be considered significant.

While the implementation of the proposed measures under any of the alternatives and the cumulative actions would not result in overall beneficial impacts to Tribal subsistence and ceremonial fishing activities, effects would be less adverse than those that are currently experienced by Tribes due to dwindling fish populations in the WRB. Though beneficial effects from the effective implementation of RFFAs 5, 6, 7, and 8 could offset some of the adverse effects from RFFAs 1, 3, and 9, these are not expected to change the severity of adverse effects. Overall, long-term adverse cumulative effects to Tribes engaged in subsistence and ceremonial fishing in the ROI would range from minor to moderate in magnitude; and be the least adverse under Alternatives 3a and 3b. These effects would be disproportionately high and adverse, but would not be significant.

## 4.21 CULTURAL RESOURCES

### 4.21.1 Cumulative Effects Analysis Methodology for Cultural Resources

#### *4.21.1.1 Cumulative Actions Applicable to Cultural Resources*

Past, present, and RFFAs that, when considered together with the Proposed Action and alternatives, would have cumulative effects on Cultural Resources, include:

- WVS Dams and Reservoirs: construction and past operations and maintenance (see section 4.2.1.1).
- WVS Dams and Reservoirs: ongoing operations and maintenance (see section 4.2.2).
- RFFA 1: Future population growth and accompanying urban, industrial, and commercial development.
- RFFA 5: Federal and state wildlife and lands management.
- RFFA 7: Tribal, state, and local fish and wildlife improvement.
- RFFA 9: Climate change.
- RFFA 10: Mining operations.
- RFFA 11: Timber and logging industry operations.

See Tables 4.21-1 and 4.21-2 for description of the cumulative impacts to Cultural Resources.

**Table 4.21-1. Summary of Past and Present Actions Relevant to Cultural Resources**

| Action | Description | Cumulative Impact Description |
|---|---|---|
| Past | WVS Dams and Reservoirs: construction and past operations and maintenance | Activities related to construction and the 50-80 years of fill and drawdown cycle of the reservoir resulted in additive, major, and adverse effects to archaeological sites through disturbance, erosion, and exposure, and traditional cultural properties through reduced and restricted access to tribal members and actions that have impacted habitat and water quality as well as destruction of archaeological sites that are part of traditional cultural properties.<br><br>It also resulted in the construction of the WVS which is composed of 13 historic districts. Management and operations have been mostly beneficial through retainment of historic fabric of the 13 historic districts. Some modification or removal of some contributing resources in the past have had minor adverse cumulative effects. |

| Action | Description | Cumulative Impact Description |
|---|---|---|
| Present | WVS Dams and Reservoirs: ongoing operations and maintenance | Continued draft and fill cycle is an irreversible, additive and incremental adverse cumulative effect to archaeological sites due to active erosion and exposure.<br><br>Actions that support improved habitat and water quality would have beneficial impacts to traditional cultural properties. The continued existence of the WVS restricts and reduces tribal access to traditional cultural properties which is a major adverse cumulative impact that is potentially reversible.<br><br>Current operations to not include additions or modifications to the historic built environment, which is a beneficial cumulative effect. |

**Table 4.21-2. Summary of Reasonably Foreseeable Future Actions (RFFA) Relevant to Cultural Resources**

| RFFA # | RFFA Description | Cumulative Impact Description |
|---|---|---|
| RFFA 1 | Future population growth and urban, industrial, and commercial development | Adverse effect to archaeological sites due to increased looting, traditional cultural properties through competition for access and resources important to Indian tribes and built resources that experience degradation due to increased visitor use. |
| RFFA 5 | Federal and State Wildlife and Lands Management | Varies, could be beneficial or adverse depending on management action. |
| RFFA 7 | Tribal, State, and local fish and wildlife improvement | Varies, could be beneficial or adverse depending on improvement action. |
| RFFA 9 | Climate change | Adverse effect due to increased winter precipitation that erodes archaeological sites, reduced water levels in the summer that expose archaeological sites, both would increase looting and vandalism to archaeological sites. Adverse effect to traditional cultural properties through reduced/degraded water quality and habitat of species important to Indian tribes. Wildfire would negatively affect all types of cultural resources. |
| RFFA 10 | Mining operations | Localized to mining operation, direct adverse effects to archaeological sites (erosion) and traditional cultural properties downstream habitat and water quality degradation), but unlikely to affect built resources. |
| RFFA 11 | Timber and logging industry operations | Direct effects localized to logging unit, where ground disturbance can negatively affect archaeological sites, but indirect effects could negatively affect viewshed of 13 historic districts (built resources) and traditional cultural properties on decadal scale. Indirect effects would be temporary. |

Some of the other RFFAs discussed in section 4.2.3 would not occur at or in close proximity to the WVS dams and reservoirs and as such would not have a cumulative effect on Cultural Resources located in the WVS. (Had they occurred at or in close proximity to the WVS dams and reservoirs, they would have contributed to cumulative effects for Cultural Resources).

- RFFA 2: Future agricultural development.
- RFFA 3: Water withdrawals for municipal, industrial, and agricultural uses.
- RFFA 4: Decarbonizing the energy sector with renewable energy sources.
- RFFA 6: Fishery management and Killer Whales.
- RFFA 8: Invasive species management.

Therefore, these RFFAs are dismissed from further analysis.

### 4.21.2 Cumulative Effects to Cultural Resources by Alternative

Construction of the Willamette Valley dams and reservoirs has had major adverse irreversible effects to cultural resources in the WVS. The clearing of large swaths of timbered land directly impacted archaeological sites through logging practices that caused major ground disturbance and damaged the physical integrity of the archaeological sites. The rerouting of historic infrastructure (roads and railways) and the building of new linear infrastructure also disturbed archaeological sites through major ground disturbance. These actions impacted historic buildings, roads, trails, etc., that were present prior to construction of the WVS. The building of the dams and reservoirs displaced several historic communities (such as Old Detroit, Hebron, Lowell, Dorena, and Winberry) and rural homesteads spread throughout the six subbasins. In general, construction of the WVS directly and adversely impacted archaeological sites through major ground disturbance on a massive scale (thousands of acres per each of the 13 WVS projects), and greatly changed the historic nature of the pastoral or timbered landscape of rural Oregon. These historic communities and homesteads, many of which were Donation Land Claims, were deeply connected to the development of the State of Oregon. The eventual filling and use of the 13 reservoirs further directly adversely affected cultural resources through submersion and disruption of the recently disturbed sediments (from timber clearing, road building, etc.). Tribal individuals and communities lost access to portions of their usual and accustomed areas and the landscape that existed prior to construction of the WVS that today would be identified as a landscape of traditional cultural properties.

The construction of the WVS ultimately created another series of cultural resources – the built environment of the 13 historic districts that comprise the WVS. The past operations have retained much of the historic fabric of the WVS dams and reservoirs, constructed between 1940 and 1969, and Corps management of this aspect of the WVS infrastructure has been immensely beneficial. Other historic infrastructure has been neglected, such as old engineering offices, or removed, such as non-functioning gantry cranes, and these are minor to moderate adverse effects to elements that contribute to the aesthetic of the historic districts.

The past annual cycles of drawdown and fill of the reservoirs, occurring over 50 to 80 years depending on the Project, has had major direct adverse effects to cultural resources that are located within or overlap with the reservoir as discussed in section 3.21. This action has created an annual cycle of erosion that incrementally destroys the physical integrity of sites and exposure that increases each site's vulnerability to illicit collection and other forms of human-caused destruction. The annual cycles of erosion and exposure have caused incremental impacts that have had major cumulative impacts over the last five to eight decades and these impacts are irreversible and additive. Archaeological sites cannot be remade, refurbished, or reconstructed once any part of the physical makeup is disturbed. Current operations include annual drawdown and fill of the reservoirs, which continues to have major direct adverse effects to archaeological sites in and around the reservoirs. As discussed in section 3.21.3.3.1, several near-term operations would have direct adverse effects from deep drawdowns at several of the reservoirs and operations that would result in reservoir elevation change, both that will increase erosion and exposure of archaeological sites. The built environment would also be directly adversely affected by structural modifications and additions that change the historic fabric of the 13 historic districts of the WVS.

Future population growth, urban, industrial, and commercial development (RFFA 1) may cause direct adverse effects due to an increase in the number of people who recreate at the 13 reservoirs. This would result in an uptick of illicit collection when archaeological sites are exposed during low water levels and damage from other human impacts such as unauthorized vehicle use in the reservoirs. The continued illicit removal of artifacts from archaeological sites is irreversible and additive. Increased population would also result in more resource extraction in the WVS that could lead to direct effects from actions such as mineral extraction, logging operations, floodplain development, and dredging and sediment management. Increased use of the WVS could also adversely affect traditional cultural properties by creating competition for access to locations and resources important to Indian tribes. Built resources, particularly those at recreation sites, may experience heavier use and related degradation that would directly and adversely impact the aspects that qualify them as contributing to the 13 historic districts.

Federal and State Wildlife and Land Management (RFFA 5) may have adverse or beneficial direct and indirect effects to Cultural Resources in the WVS. This is dependent on how resources and lands are managed. If the result is to stabilize landscapes through encouraging native vegetation, this would be directly beneficial to archaeological sites that would have reduced exposure and visibility to people who may illegally collect artifacts. It would also have the indirect result of improving the aesthetics and viewshed of places that are important to Indian tribes. If the result is to return a waterway to pre-dam conditions and required the removal of historic built environment or ground disturbance that impacts archeological sites, this could have direct adverse effects to cultural resources. Management actions that improve tribal access to usual and accustomed areas as well as habitat and environment, this would have beneficial effects on traditional cultural properties (even if built resources and archaeological sites are adversely impacted).

Tribal, state, and local fish and wildlife improvement (RFFA 7) may be beneficial to some cultural resources for the same reasons discussed for RFFA 5. Management strategies that prioritize habitat improvement and water quality benefit tribal communities and places identified as traditional cultural properties. However, these actions have the potential to negatively affect the built environment and archaeological sites that may be removed or damaged by ground-disturbing aspects of conservation and restoration efforts.

Climate Change (RFFA 9) would have negative direct effects to cultural resources, as discussed in section 3.21. Notable impacts would include more winter rains that would increase erosion of exposed reservoir beds and cause instability to archaeological components. This would also expose more artifacts to illicit collection. Less water in the summer would cause similar issues for sites by leaving more reservoir bed exposed when people are flocking to shoreline recreation sites and would have easy access to exposed non-vegetated reservoir beds. Increased wildfires are a major negative direct impact to WVS cultural resources. Fires destabilize soils and denude forests which cause erosion at archaeological sites. Reduced vegetation also increases visibility of archaeological sites and leaves them vulnerable to illicit collection. Changes to landscape also could lead to greater high-water events that weaken soils and increase erosion and channel incision both negatively directly affecting cultural resources. Unchecked wildfire (as opposed to controlled burns) destroys habitat and creates unsafe wilderness that reduces tribal access to traditional cultural properties.

Mining operations (RFFA 10) have the potential to directly and indirectly adversely affect cultural resources when they occur within the WVS. Operations that disturb soils along the banks cut into existing archaeological sites as well as create unstable banks that are more likely to erode and would indirectly affect archaeological sites downstream from the mining operations.

Timber and logging industry operations (RFFA 11) are declining in western Oregon and low in the Willamette Valley when compared to other western Oregon physiographic provinces. However, many of the WVS dams and reservoirs are located in timber country and surrounded by private timber company inholdings and the Willamette National Forest, and the agency actively manages the forests for timber products and fire reduction. Timber operations that occur near or in the WVS have the potential to directly and indirectly negatively affect archaeological sites through ground disturbance, soil instability, and water runoff in newly unvegetated areas. They can also create indirect effects through modification of the forested viewshed (as can mining operations). While the WVS is a human constructed entity, the 13 Projects are nestled into pastoral or timbered landscapes, and they are places where people go to recreate and enjoy the natural setting. This aesthetic is important to the appeal of the 13 historic districts. The impacts to the viewshed, however, are temporary, though they may last several decades. Noise from these operations would be another potential indirect effect that could adversely affect the aesthetic of the historic environment.

The following considers the effects of the proposed alternatives and cumulative actions outlined in Chapter 4 on Cultural Resources. The discussion is organized by resource type: archaeological sites, traditional cultural properties, and built resources.

#### *4.21.2.1 No Action Alternative*

The No Action Alternative (NAA) maintains an annual draft and fill cycle that has major direct irreversible adverse effects to 80% of archaeological sites documented in the WVS, as discussed in section 3.21. This draft and fill erodes archaeological sites that overlap with the reservoirs and exposes these sites to illicit collection and other human-caused damage. RFFA 1 and 9 would have additive, major, and adverse effects to archaeological sites. Archaeological sites in the WVS have already experienced major irreversible impacts from the construction of the WVS dams and reservoirs and have experienced five to eight decades of draft and fill cycles. Increased recreation at the WVS will further exacerbate looting and illicit collection that degrades the integrity of archaeological sites. Climate change that results in increased erosion of reservoir beds in the winter and increased exposure of reservoir beds in the spring and summer will have similar impacts. The deep drawdowns at Fall Creek continue to increase the erosion and exposure of archaeological sites present at this reservoir.

Traditional cultural properties are not well documented in the WVS, but it is assumed that they are present given the lengthy habitation of the Willamette Valley by indigenous communities as discussed in section 3.21. The construction and continued operation of the WVS has had major direct adverse effects to traditional cultural properties including archaeological sites, habitat, and water quality as well as reduced and restricted access to the lands that now comprise the WVS. The cumulative effects of past and present actions and RRFAs 1 and 10 are major and adverse. There is potential to reverse some of these negative effect through management actions that improve habitat, water quality, and access to them by tribal communities. Potentially, RFFAs 5 and 7 would have beneficial effects to traditional cultural properties, but with RFFA 1 and 10 tribal communities may be forced to compete for access and resources as more people move into the Willamette Valley. The archaeological components of traditional cultural properties cannot be rehabilitated, but increased access by tribal members would provide a beneficial cumulative effect. RFFA 10 and 11, which would adversely impact the viewsheds of traditional cultural properties, have the potential to cause minor to moderate cumulative impacts. The existence of the WVS has already significantly directly and indirectly impacted traditional cultural properties in the six sub-basins, so continued resource extraction would not greatly increase the negative effects.

No new construction or modification to the 13 historic districts is considered under the NAA, but increased visitor use and resource extraction (RFFA 10 and 11) have the potential to directly and indirectly impact historic recreation sites that are present in the WVS. Over time, this could result in minor to moderate adverse cumulative effects, but these could be minimized or reversed through maintenance plans and recreation management plans that prioritize maintaining the historic aesthetic and viewshed of the WVS.

#### *4.21.2.2 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Alternative 1 and the NAA both follow a rule curve that includes an annual draft and fill cycle of WVS reservoirs and a deep drawdown at Fall Creek. Alternative 1 combined with past, present, and reasonably foreseeable actions would have similar direct, indirect, and cumulative effects to archaeological sites and traditional cultural properties as the NAA. For archaeological sites, the cumulative effects are major, additive, irreversible, and adverse. For traditional cultural properties, the cumulative effects vary from beneficial to adverse, but most are potentially reversible with the exception of the destruction of archaeological sites that may be part of traditional cultural properties, as described for the NAA (preceding section).

Alternative 1 deviates from the NAA in the management of built resources, which includes structural modifications to seven of the historic districts including Fern Ridge, Dexter, Lookout Point, Cougar, Foster, Green Peter, and Detroit and would have moderate to major direct effects. Overall, the cumulative effects do not increase adverse effects or create beneficial effects beyond what is discussed in section 3.21.

#### *4.21.2.3 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Like the NAA and Alterative 1, Alternative 2A follows a rule curve that results in one major cycle of draft and fill per water year, which has major direct irreversible adverse effects to archaeological resources. Alternative 2A proposes a deep fall drawdown at Green Peter (780 feet) and Fall Creek as opposed to just Fall Creek (with the NAA and Alternative 1). This would increase negative erosion and exposure of archaeological sites that will occur at two reservoirs. Similar to the NAA and Alternative 1, the cumulative effects of past, present, and reasonably foreseeable actions combined with Alternative 2A will be additive, major, and adverse to archaeological sites.

Traditional cultural properties would have similar and varying cumulative impacts as described in the NAA and Alternative 1 sections. Built resource cumulative impacts would be similar to those described for Alternative 1 but occur at six projects (rather than seven as in Alternative 1) including Dexter, Lookout Point, Cougar, Foster, Green Peter, and Detroit.

#### *4.21.2.4 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Like the NAA and Alterative 1, Alternative 2A follows a rule curve that results in one major cycle of draft and fill per water year, which has major direct irreversible adverse effects to archaeological resources. Alternative 2A proposes a deep fall drawdown at Green Peter (780 feet) and Fall Creek as opposed to just Fall Creek (with the NAA and Alternative 1). This is an increase in negative erosion and exposure of archaeological sites that will occur at two reservoirs. Similar to the NAA and Alternative 1, the cumulative effects of past, present, and reasonably foreseeable actions combined with Alternative 2A will be additive, major, and adverse to archaeological sites.

Traditional cultural properties will be similarly cumulatively impacted as described in the NAA and Alternative 1 sections. Built resource cumulative impacts would be similar to those described for Alternative 1 and occur at the same six reservoirs listed in Alternative 2A.

#### *4.21.2.5 Alternative 3A – Operations-Focused Fish Passage Alternative*

The NAA, Alternative 1, Alternative 2A, Alternative 2B, and Alternative 3A have an annual cycle of draft and fill of the reservoirs, which have direct, irreversible, adverse effects to archaeological sites. Alternative 3 would strongly accelerate major direct adverse effects to archaeological sites with proposed deep drawdowns at six reservoirs including Blue River, Hills Creek, Green Peter, Detroit, Lookout Point, and Cougar. Alternative 3 combined with past, present, and reasonably foreseeable actions would have the greatest adverse additive impacts to archaeological sites.

Traditional cultural properties would likely have adverse cumulative effects that are greater than those described in the NAA, Alternative 1, Alternative 2A, and Alternative 2B, but this resource type is not well documented in the WVS and cannot be fully discussed other than to note that there are tradeoffs to measures that negatively affect archaeological sites that are part of traditional cultural properties but would benefit habitat and water quality.

Alternative 3A would have less adverse cumulative effects to built resources than Alternative 1, Alternative 2A, and Alternative 2B, but more than the NAA. Modifications would occur at four of the historic districts including Hills Creek, Cougar, Blue River, and Green Peter.

#### *4.21.2.6 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)*

Alterative 3B shares similarities with 3A, but is quite different from the NAA, Alternative 1, Alternative 2A, and Alternative 2B. Fall deep drawdowns are proposed for the same six reservoirs including Blue River, Hills Creek, Green Peter, Detroit, Lookout Point, and Cougar. Spring deep drawdowns, however, are proposed at Hills Creek, Cougar, and Green Peter. In both of these alternatives, Cougar will have a spring and fall deep drawdown. In Alternative 3B, the fall deep drawdown will pass through the diversion tunnel. Like Alternative 3A, these actions will have major irreversible direct adverse effects to archaeological sites, more so than the NAA, Alternative 1, Alternative 2A, and Alternative 2B. Severe additive and adverse cumulative impacts to archaeological sites would occur with Alternatives 3A and 3B.

There would likely be greater adverse cumulative effects to traditional cultural properties (TCPs) than those described in the NAA, Alternative 1, Alternative 2A, and Alternative 2B, and similar to those that would occur with Alternative 3A. However, this resource type is not well documented in the WVS and cannot be fully discussed other than to note that there are tradeoffs to measures that negatively affect archaeological sites that are part of traditional cultural properties but would benefit habitat and water quality.

Alternative 3B would have less adverse cumulative effects to built resources than Alternative 1, Alternative 2A, and Alternative 2B, more than the NAA, and similar to Alternative 3A. Modifications would occur at the same four of the historic districts including Hills Creek, Cougar, Blue River, and Green Peter.

#### *4.21.2.7 Alternative 4 – Structures-Based Fish Passage Alternative*

Alternative 4 follows a rule curve that results in one major cycle of draft and fill per water year and is similar to Alternative 1 in regard to impacts to archaeological resources. The impacts are also similar to the NAA. Alternative 4, however, does not propose any deep drawdowns or spring spills over the spillway, which differs greatly from Alternative 2A, Alternative 2B, Alternative 3A, and Alternative 3B. Rather this alternative focuses heavily on structure-based measures to accomplish downstream fish passage. As with the NAA, the WVS cycle of draft and fill will continue to greatly, directly, irreversibly, and adversely affect 369 (80%) of the archaeological sites present in the WVS.

Cumulative impacts to traditional cultural properties are anticipated to be similar to those described in the NAA and Alternative 1, and less impactful than Alternatives 2A, 2B, 3A, and 3B that would have greatly increased adverse effects to archaeological sites.

Alternative 4 would cause the most direct adverse effects to built resources including seven historic districts: Dexter, Lookout Point, Hills Creek, Cougar, Foster, Big Cliff, and Detroit with the exception of Alternative 1. All of the other alternatives would have some adverse impact to built resources except the NAA which does not propose any modifications to the built environment.

#### *4.21.2.8 Alternative 5 – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar Drawdown to Diversion Tunnel)*

Alternative 5 and all of the other alternatives follow a rule curve that results in one major cycle of draft and fill per water year, which has major direct irreversible adverse effects to archaeological resources. Alternative 5 proposes a deep fall drawdown at Green Peter (780 feet) and Fall Creek as opposed to just Fall Creek (with the NAA and Alternative 1). This is an increase in negative erosion and exposure of archaeological sites that will occur at two reservoirs. Similar to the NAA and Alternative 1, the cumulative effects of past, present, and reasonably foreseeable actions combined with Alternative 2A will be additive, major, and adverse to archaeological sites.

Traditional cultural properties would have cumulative impacts similar to those described in the NAA and Alternative 1 sections. Built resource cumulative impacts would be similar to those described for Alternative 1 and occur at the same six reservoirs listed in Alternative 2A.

## 4.22 VISUAL RESOURCES

This section discusses the cumulative effects on visual resources. This includes a discussion of the effects of proposed measures considered alongside applicable cumulative actions, and how each project alternative would cumulatively affect visual resources. The geographic scope for visual resources would be the same boundary as described in the Affected Environment in Chapter 3, which includes the nine project locations of Lookout Point, Detroit, Green Peter, Hills Creek, Dexter, Cougar, Blue River, Foster, and Fall Creek Dams within the WRB.

### 4.22.1 Cumulative Actions Applicable to Visual Resources

Past, present, and reasonably foreseeable future actions that, when considered together with the Proposed Action and alternatives, would have cumulative effects on visual resources, include:

- Construction of the WVS dams and supporting structures;
- Modifications of existing WVS structures at Dexter, Big Cliff, and Cougar;
- Water quality management;
- Transportation corridor development;
- RFFA 1, future population growth and accompanying urban, industrial, and commercial development;
- RFFA 3, water withdrawals for municipal, industrial, and agricultural uses;
- RFFA 4, decarbonizing the energy sector with renewable energy sources;
- RFFA 5, federal and state wildlife and lands management;
- RFFA 7, tribal, state, and local fish and wildlife improvement; and
- RFFA 9, climate change.

Some of the other RFFAs discussed in Section 4.2.3 would not have a cumulative effect on visual resources. These include RFFA 6, fishery management and killer whales; and RFFA 8, invasive species management. These actions do not contribute to visual resources; thus, these RFFAs are not discussed further in this cumulative effects analysis. Other RFFAs could have contributed to cumulative effects for visual resources had they occurred at or in closer proximity to the WVS dams and reservoirs. These include RFFA 2, reduced agricultural production; RFFA 10, mining operations; and RFFA 11, timber and logging industry operations. Agricultural lands, mining operations, and timber and logging operations are not visible within the viewshed of project locations, and there are no planned projects or projected changes for the foreseeable future. Therefore, these RFFAs are not discussed further in this cumulative effects analysis. Renewable energy structures only include hydropower from the existing dams and supporting structures as described in Chapter 3; there are no proposed renewable energy projects within the counties representing the WRB.

### 4.22.2 Discussion of Cumulative Effects by Measure(s)

This section considers the proposed measures with applicable cumulative actions to determine the potential cumulative effect to visual resources. Where possible, the discussion of cumulative effects is grouped by measures that would have similar effects.

#### *4.22.2.1 Construct water temperature control (WTC) towers (#105), Construct structural downstream fish passage (#392), and Construct adult fish facilities (AFFs) (#722)*

As discussed in Section 3.22.4.3.1, the magnitude of adverse effects from the construction of WTC towers (#105), structural downstream fish passages (#392), and AFFs (#722) would be minor in the short, medium, and long term, as these structures would be seen but would not attract attention and would not dominate the landscape.

Land management (e.g., chemical and mechanical treatments to vegetation, tree-trimming activities), fish and wildlife management (e.g., removing a series of gravel pits and barriers acting as levees and allowed the river to return to its natural, free-flowing state), and water quality management (e.g., monitoring water quality, water levels, and water uses) would have the same short-term, adverse effects as the construction of structural downstream fish passages and adult fish facilities. Work vehicles, machinery, and building materials similar to those used for the proposed measures would likely be used for the cumulative actions, and would be visible during the duration of the construction phase. As such, short- and medium-term, cumulative effects would be minor, additive and adverse. In the long term, these activities would generally align with the class management objectives and contribute to retaining or partially retaining the existing character of the landscape. Long-term, cumulative effects would be minor, countervailing and beneficial.

Modifications of existing WVS structures at Dexter, Big Cliff, and Cougar and the erection of buildings or infrastructure due to population growth and associated urban landscape development, and transportation corridor development would have similar short, medium, and long- term, minor adverse effects on visual resources as the construction of WTC towers, structural downstream fish passages, and AFFs. Modifications of existing WVS structures would include upgrades to the existing Dexter AFF, a structural solution for mitigating excess TDG levels during spill operations at Big Cliff, and a structural solution to improve and/or modify Cougar Dam's ROs to ensure safer fish passage and reduced TDG levels. The type, location, and size of these actions are very similar to measures proposed in the action alternatives. Work vehicles, machinery, and building materials similar to those used for the proposed measures would likely be used for all the aforementioned cumulative actions, and would be visible during the duration of the construction phase. As such, short- and medium-term, cumulative effects of the proposed structural measures in combination with cumulative actions that include development and the construction or modification of structures would be minor, additive and adverse. Ultimately these structures would be seen but would not attract attention and would not dominate the landscape. These cumulative actions – in particular the modifications of existing WVS structures at Dexter, Big Cliff, and Cougar would alter the landscape towards a more urban and industrial character because they would at the project locations. Most project locations already include USACE infrastructure in the forms of dams and supporting structures that have been in place for several decades. As described in 3.22.4, construction of all structural measures would be consistent with Class II, III, or IV management activities; modifications of existing WVS structures at Dexter, Big Cliff, and Cougar would be no different. Many of the project locations already feature two-lane highways, small paved parking lots at viewpoints, and other small buildings that contribute urban features to the landscape. The City of Lowell is within the viewshed of Dexter and Lookout Point Dams and Reservoirs; the City of Detroit is located on the northeastern shores of the Detroit Reservoir; and the City of Sweet Home has sprawled all the way to the shores of Foster Reservoir. As such, long-term cumulative effects of proposed structural measures in combination with cumulative actions that include development and the construction or modification of structures would be minor, additive and adverse.

Indirect effects from development would include nonpoint source pollution or stormwater runoff, which affects the quality and aesthetics of the receiving waterbodies, such as the tributaries and reservoirs within the viewshed. Climate change would also adversely affect visual resources through increased forest fires, longer and more arid drought seasons, and smaller winter snowpacks – all of which would noticeably alter the landscape with lower riverine flows and more arid conditions, or drastically alter the landscape through destructive natural disasters. Warmer temperatures from climate change could also provide favorable conditions for the propagation of harmful algal blooms (HABs), which can discolor, cloud, or cover the water's surface and affect visual resources. Wildfire intensity and frequency associated with climate change would drastically alter the basic design elements of a forested, natural landscape by substantially changing the color, form, and texture due to the burnt, darkened, and decimated landscapes that follow wildfires. Wildfire ash can also land in reservoirs, streams, and rivers, increasing turbidity and affecting the visual resources of those water bodies. Some of these effects would continue to be minimized by actions to conserve and protect the natural features of the landscape in wildlife refuges, preserves, national forests, and through other land management strategies. These actions have already been undertaken at many project sites through the creation of parks, recreational reservoirs and beaches, and wildlife trails. Short- and medium-term cumulative effects of the proposed structural measures in combination with non-point source pollution, stormwater runoff, and climate change would have minor, additive and adverse effects due to increased turbidity and the effect on the quality and aesthetics of the reservoirs.

Continuing with the visual contrast rating system used to determine potential effects by VRM Class Management Objectives in Section 3.22.4, it is generally assumed that the natural landscape is valued and the more dominant the change, the more adverse the effect. Overall, the characteristic landscape at project locations already includes a mixture of natural and urban features due to the longevity of existing USACE infrastructure that is set within the backdrop of a natural landscape. Therefore, when considered in tandem with the construction of WTC towers, structural downstream fish passages, and AFFs, applicable cumulative actions would create adverse, additive, and minor cumulative effects to visual resources in the short, medium, and long term. In the long term, land management, fish and wildlife management, and water quality management activities in combination with the proposed structural measures would have cumulative effects that are minor, countervailing and beneficial.

#### *4.22.2.2 Fall Creek drawdown, Deeper fall reservoir drawdowns for fish passage (#40), and Spring reservoir drawdown for downstream fish passage (#720)*

As discussed in Section 3.22.4.3.2, the magnitude of adverse effects from deeper fall reservoir drawdowns (#40) and spring reservoir drawdowns (#720) would be moderate in the short term and major in the long term, as these drawdowns would demand attention, cannot be overlooked, and would dominate the landscapes. O&M of USACE infrastructure (e.g., reservoir drawdowns), water withdrawals, and climate change would have the same types of effects on visual resources as reservoir drawdowns and would demand attention, cannot be overlooked, and would dominate the landscape. Most project locations already include decades-old USACE infrastructure in the forms of dams and reservoirs, whose water levels change based on project location, reservoir purpose, and seasonality. Reservoir storage is typically at its peak during the summer months, lowest during the winter months, and in a transition period during the fall and spring seasons. Detroit and Foster Reservoirs have high recreational demand within the WVS, and reservoirs levels are maintained high until early September to accommodate recreational users. Water withdrawals of stored water include projected allocations over the next fifty years for fish and wildlife (F&W), municipal and industrial (M&I) water supply, and agricultural irrigation (AI), with F&W demanding the large majority of water usage (1,102,600 acre-ft) and AI and M&I water demands making up much smaller allocations (327,650 and 159,750 acre-feet, respectively).

Climate change would contribute to cumulative effects for visual resources through longer, more arid drought seasons and smaller snowpacks, which affect reservoir storage capacity. Climate change could also exacerbate long-term, recurring effects from drawdowns and further change the basic design elements of color, texture, and form. If reservoir levels are already lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity; affecting water color and clarity. This would have a noticeable effect on the basic design elements of color, texture, and form. Color would change slightly to a darker color with the introduction of darker clays, silts, and sediments; texture would change slightly with the introduction of grainy sediment particles and other larger suspended particulate materials; and form would change slightly with the introduction of a variety of irregular shapes, sizes, and masses from the suspended solids.

When considered together with reservoir drawdowns, O&M of USACE infrastructure, water withdrawals, and climate change would have adverse, additive, and moderate short-term and major long-term cumulative effects to visual resources.

### 4.22.3 Discussion of Cumulative Effects by Alternative

This section analyzes the relevant cumulative actions by alternative to determine the potential cumulative effects to visual resources.

#### *4.22.3.1 No Action Alternative*

The NAA would include basin-wide measures along the Willamette River including maintaining revetments using nature-based engineering or altering revetments for aquatic ecosystem restoration (#9). Revetments were not considered key elements to visual resources as they do not occur at the 13 USACE dams and reservoirs and the locations of revetments cannot be seen from project locations. Similarly, cumulative actions along the Willamette River that cannot be seen from project locations would have negligible effects on visual resources.

The NAA would also include Fall Creek reservoir drawdowns annually to its lowest outlet for a few weeks in late fall and have moderate, short-term effects and major long-term and recurring effects. Water withdrawals of stored water for fish and wildlife (F&W), municipal and industrial (M&I) water supply, and agricultural irrigation (AI) would further exacerbate these effects. And as described above, climate change could further change the basic design elements of color, texture, and form. If reservoir levels are already lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity; affecting water color, clarity, and texture. Therefore, cumulative short- and long-term effects from the Fall Creek Drawdown in combination with F&W, M&I, and AI water withdrawals and climate change would be major and adverse.

#### *4.22.3.2 Alternative 1. Improve Fish Passage Through Storage-Focused Measures*

Under Alternative 1, three WTC towers, three structural downstream fish passages, and one AFF would be constructed, affecting four project locations – Detroit, Green Peter, Lookout Point, and Foster Dams. As discussed above in Section 4.22.2.1 and 4.22.2.2, these measures in combination with modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; the erection of buildings or infrastructure due to population growth and associated urban landscape development; and transportation corridor development would have adverse, additive, minor cumulative effects in the short, medium, and long term. Cumulative effects would be more severe at Foster Dam and Reservoir (Class II area) due to the visibility of the City of Sweet Home within its viewshed and the reservoir's high recreational demand; and Detroit Dam and Reservoir (Class III area) due to the reservoir's high recreational demand. Alternative 1 would have the same cumulative effect as Alternative 4, but would be less severe compared to Alternative 2A, 2B, 3A, 3B, and 5. Any new structures under Alternative 1 would represent a considerably small contribution to overall cumulative effects on visual resources when compared to all past, present, and reasonably foreseeable actions and within the WRB landscape as a whole.

As described in Section 4.22.2.2 and the NAA, water withdrawals of stored water for F&W, M&I water supply, and AI would further exacerbate the moderate, short-term and major, long-term, recurring effects from the Fall Creek Drawdown. And as described above, climate change could further change the basic design elements of color, texture, and form. If reservoir levels are already lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity; affecting water color, clarity, and texture. Therefore, cumulative short- and long-term effects from the Fall Creek Drawdown in combination with F&W, M&I, and AI water withdrawals and climate change would be major and adverse.

#### *4.22.3.3 Alternative 2A. Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam)*

Under Alternative 2A, one WTC tower, four structural downstream fish passages, and one AFF would be permanently built, and one reservoir would be drawn down annually, affecting five project locations at Detroit, Green Peter, Lookout Point, Foster, and Cougar Dams. As discussed above in Sections 4.22.2.1 and 4.22.2.2, these measures in combination with modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; the erection of buildings or infrastructure due to population growth and associated urban landscape development; and transportation corridor development would have adverse, additive, minor to major cumulative effects in the short, medium, and long term. Cumulative effects would be more severe at Foster Dam and Reservoir (Class II area) due to the visibility of the City of Sweet Home within its viewshed and the reservoir's high recreational demand; and Detroit Dam and Reservoir (Class III area) due to the reservoir's high recreational demand. Alternative 2A would have the same cumulative effect as Alternative 2B, 3A, 3B, and 5, but would be more severe compared to Alternatives 1 and 4 due to the reservoir drawdown. However, any new structures or drawdowns under Alternative 2A would represent a small contribution to overall cumulative effects on visual resources when compared to all past, present, and reasonably foreseeable actions and within the WRB landscape as a whole.

As described in Section 4.22.2.2 and the NAA, water withdrawals of stored water for F&W, M&I water supply, and AI would further exacerbate the moderate, short-term and major, long-term, recurring effects from the Fall Creek Drawdown and other drawdowns occurring under Alternative 2A. And as described above, climate change could further change the basic design elements of color, texture, and form. If reservoir levels are already lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity; affecting water color, clarity, and texture. Therefore, cumulative short- and long-term effects from the Fall Creek Drawdown and other drawdowns in combination with F&W, M&I, and AI water withdrawals and climate change would be major and adverse.

#### *4.22.3.4 Alternative 2B. Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Under Alternative 2B, the cumulative effects to visual resources would be the same as those described under Alternative 2A. Under this alternative, one fewer downstream passage structure would be built, and fall and spring reservoir drawdowns would occur at Cougar in addition to fall reservoir drawdowns occurring at Green Peter. As discussed above in Section 4.22.2.1 and 4.22.2.2, these measures in combination with modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; the erection of buildings or infrastructure due to population growth and associated urban landscape development; and transportation corridor development would contribute adverse, additive, minor to major cumulative effects in the short, medium, and long term. Alternative 2B would have the same cumulative effect as Alternative 2A, 3A, 3B, and 5, but would be more severe compared to Alternatives 1 and 4. However, any new structures or drawdowns under Alternative 2B would represent a small contribution to overall cumulative effects on visual resources when compared to all past, present, and reasonably foreseeable actions and within the WRB landscape as a whole.

As described in Section 4.22.2.2 and the NAA, water withdrawals of stored water for F&W, M&I water supply, and AI would further exacerbate the moderate, short-term and major, long-term, recurring effects from the Fall Creek Drawdown and other drawdowns occurring under Alternative 2B. And as described above, climate change could further change the basic design elements of color, texture, and form. If reservoir levels are already lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity; affecting water color, clarity, and texture. Therefore, cumulative short- and long-term effects from the Fall Creek Drawdown and other drawdowns in combination with F&W, M&I, and AI water withdrawals and climate change would be major and adverse.

#### *4.22.3.5 Alternative 3A. Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)*

Under Alternative 3A, three AFFs would be constructed, three reservoirs would be drawn down semiannually, and three reservoirs would be drawn down annually, affecting six project locations at Detroit, Green Peter, Lookout Point, Cougar, Blue River, and Hills Creek Dams. As discussed above in Sections 4.22.2.1 and 4.22.2.2, these measures in combination with modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; the erection of buildings or infrastructure due to population growth and associated urban landscape development; and transportation corridor development would have adverse, additive, minor to major cumulative effects in the short, medium, and long term. Cumulative effects would be more severe at Detroit Dam and Reservoir (Class III area) due to the reservoir's high recreational demand. Alternative 3A would have the same cumulative effect as Alternative 2A, 2B, 3B, and 5, but would be more severe compared to Alternative 1 and 4. Alternative 3A (and 3B, discussed below) would have the most severe adverse cumulative effects to visual resources compared to other alternatives. Reservoir drawdowns would be a main component of these two alternatives, with a total of 10 drawdowns across seven reservoirs per year (including Fall Creek). However, any new structures or drawdowns under Alternative 3A would represent a small contribution to overall cumulative effects on visual resources when compared to all past, present, and reasonably foreseeable actions and within the WRB landscape as a whole.

As described in Section 4.22.2.2 and the NAA, water withdrawals of stored water for F&W, M&I water supply, and AI would further exacerbate the moderate, short-term and major, long-term, recurring effects from the Fall Creek Drawdown and other drawdowns occurring under Alternative 3A. And as described above, climate change could further change the basic design elements of color, texture, and form. If reservoir levels are already lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity; affecting water color, clarity, and texture. Therefore, cumulative short- and long-term effects from the Fall Creek Drawdown and other drawdowns in combination with F&W, M&I, and AI water withdrawals and climate change would be major and adverse.

#### *4.22.3.6 Alternative 3B. Improve Fish Passage Through Operations-Focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Under Alternative 3B, the cumulative effects to visual resources would be the same as those described under Alternative 3A. Under this alternative, spring reservoir drawdowns would occur at Green Peter and Hills Creek instead of Detroit and Lookout Point. As discussed above in Sections 4.22.2.1 and 4.22.2.2, these measures in combination with modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; the erection of buildings or infrastructure due to population growth and associated urban landscape development; and transportation corridor development would contribute adverse, additive, minor to major cumulative effects in the short, medium, and long term. Alternative 3B would have the same cumulative effect as Alternative 2A, 2B, 3A, and 5, but would be more severe compared to Alternatives 1 and 4. Alternative 3B (and 3A, discussed above) would have the most severe adverse effects to visual resources compared to other alternatives. Reservoir drawdowns would be a main component of these two alternatives, with a total of 10 drawdowns across seven reservoirs per year (including Fall Creek). However, any new structures or drawdowns under Alternative 3B would represent a small contribution to overall cumulative effects on visual resources when compared to all past, present, and reasonably foreseeable actions and within the WRB landscape as a whole.

As described in Section 4.22.2.2 and the NAA, water withdrawals of stored water for F&W, M&I water supply, and AI would further exacerbate the moderate, short-term and major, long-term, recurring effects from the Fall Creek Drawdown and other drawdowns occurring under Alternative 3B. And as described above, climate change could further change the basic design elements of color, texture, and form. If reservoir levels are already lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity; affecting water color, clarity, and texture. Therefore, cumulative short- and long-term effects from the Fall Creek Drawdown and other drawdowns in combination with F&W, M&I, and AI water withdrawals and climate change would be major and adverse.

#### *4.22.3.7 Alternative 4. Improve Fish Passage with Structures-Based Approach*

Under Alternative 4, the cumulative effects to visual resources would be the same as those described under Alternative 1. Under this alternative, one additional downstream passage structure would be constructed, affecting a total of five project locations with the additions of Cougar and Hills Creek Dams to Alternative 1 dams (except for Green Peter Dam since it is not included in this alternative). As discussed above in Sections 4.22.2.1 and 4.22.2.2, these measures in combination with modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; the erection of buildings or infrastructure due to population growth and associated urban landscape development; and transportation corridor development would contribute adverse, additive, minor cumulative effects in the short, medium, and long term. Alternative 4 would have the same cumulative effect as Alternative 1, but would be less severe compared to Alternatives 2A, 2B, 3A, 3B, and 5. However, any new structures under Alternative 4 would represent a small contribution to overall cumulative effects on visual resources when compared to all past, present, and reasonably foreseeable actions and within the WRB landscape as a whole.

As described in Section 4.22.2.2 and the NAA, water withdrawals of stored water for F&W, M&I water supply, and AI would further exacerbate the moderate, short-term and major, long-term, recurring effects from the Fall Creek Drawdown. And as described above, climate change could further change the basic design elements of color, texture, and form. If reservoir levels are already lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity; affecting water color, clarity, and texture. Therefore, cumulative short- and long-term effects from the Fall Creek Drawdown in combination with F&W, M&I, and AI water withdrawals and climate change would be major and adverse.

#### *4.22.3.8 Alternative 5. Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Under Alternative 5, the cumulative effects to visual resources would be the same as those described under Alternative 2B. As discussed above in Section 4.22.2.1 and 4.22.2.2, these measures in combination with modifications of existing WVS structures at Dexter, Big Cliff, and Cougar; the erection of buildings or infrastructure due to population growth and associated urban landscape development; and transportation corridor development would contribute adverse, additive, minor to major cumulative effects in the short, medium, and long term. Alternative 5 would have the same cumulative effect as Alternative 2A, 3A, and 3B, but would be more severe compared to Alternatives 1 and 4. However, any new structures or drawdowns under Alternative 5 would represent a small contribution to overall cumulative effects on visual resources when compared to all past, present, and reasonably foreseeable actions and within the WRB landscape as a whole.

As described in Section 4.22.2.2 and the NAA, water withdrawals of stored water for F&W, M&I water supply, and AI would further exacerbate the moderate, short-term and major, long-term, recurring effects from the Fall Creek Drawdown and other drawdowns occurring under Alternative 5. And as described above, climate change could further change the basic design elements of color, texture, and form. If reservoir levels are already lower due to low summer flows and long-lasting droughts, shoreline erosion could occur and cause sedimentation and increase turbidity; affecting water color, clarity, and texture. Therefore, cumulative short- and long-term effects from the Fall Creek Drawdown and other drawdowns in combination with F&W, M&I, and AI water withdrawals and climate change would be major and adverse.

### 4.22.4 Summary

In summary, the cumulative effects of Alternatives 2A, 2B, 3A, 3B, and 5 would be more severe compared to Alternative 1 and Alternative 4. Effects from alternatives 2A, 2B, 3A, 3B, and 5 would be adverse, additive, and minor to major in the short, medium, and long term. Alternatives 1 and 4 would have adverse, additive, minor cumulative effects in the short, medium, and long term. Cumulative short- and long-term effects from the Fall Creek drawdown would be major and adverse for all alternatives. Alternatives 3A and 3B would have the most severe cumulative effect to visual resources because reservoir drawdowns would be a main component of these two alternatives, with a total of 10 drawdowns across seven reservoirs per year (including Fall Creek).

## 4.23 NOISE

This section discusses the cumulative effects from noise. This includes a discussion of the effects of proposed measures considered with applicable cumulative actions, and how each project alternative would be cumulatively affected by noise. The geographic scope for noise would be the same boundary as described in the Affected Environment in Chapter 3, which includes the eight project locations of Lookout Point, Detroit, Green Peter, Hills Creek, Dexter, Cougar, Blue River, and Foster Dams within the WVS.

### 4.23.1 Cumulative Actions Applicable to Noise

Past, present, and reasonably foreseeable future actions that, when considered together with the Proposed Action and alternatives, would have cumulative effects from noise, include:

- Construction of the WVS dams and supporting structures;
- Transportation corridor development;
- RFFA 1, future population growth and accompanying urban, industrial, and commercial development;
- RFFA 4, decarbonizing the energy sector with renewable energy sources;
- Court-ordered expedited design and construction at Dexter, Big Cliff, and Cougar for the management and operation of the WVS and its effects on ESA-listed salmonids.

Some of the other RFFAs discussed in Section 4.2 would not occur at or in close proximity to the WVS dams and reservoirs, or would not be a meaningful source of additive noise, and as such would not have a cumulative effect on noise. These include RFFA 2, reduced agricultural production; RFFA 3, water withdrawals for municipal, industrial, and agricultural uses; RFFA 5, federal and state wildlife and lands management; RFFA 6, fishery management and killer whales; RFFA 7, tribal, state, and local fish and wildlife improvement; RFFA 8, Invasive species management; RFFA 9, climate change; RFFA 10, mining operations; and RFFA 11, timber and logging industry operations. Agricultural lands, mining operations, and timber and logging operations are not found in close proximity to project locations, and there are no planned projects or projected changes for the foreseeable future. Therefore, these RFFAs are dismissed from further analysis.

### 4.23.2 Discussion of Cumulative Effects by Measure(s)

This section considers the interaction of proposed measures with applicable cumulative actions to determine the potential cumulative effects from noise. Where possible, the discussion of cumulative effects is grouped by measures that would have similar effects.

#### *4.23.2.1 Construct water temperature control towers (#105), Construct structural downstream fish passages (#392), Provide Pacific Lamprey passage and infrastructure (#52), and Construct adult fish facility (#722)*

As discussed in Section 3.23.2.4, the magnitude of adverse effects from the construction of WTC towers, downstream passage structures, Pacific lamprey structures, and AFFs would be moderate, and the noise from constructing these structures would be limited to areas immediately surrounding the construction site. The results of population growth and associated urban landscape development (converting rural lands to developed or urban lands), transportation corridor development, and constructing renewable energy structures would have similar effects on increasing noise generation as the construction of WTC towers, downstream passage structures, Pacific lamprey structures and AFFs. Ambient sound levels would remain at background levels and be additive only in areas immediately surrounding construction sites. The project locations already include USACE infrastructure in the forms of dams and supporting structures that have been in place for many decades (over 50 years). Many of the project locations also feature two-lane highways, small paved parking lots, and other small buildings that contribute additive background levels of noise.

Renewable energy structures only include hydropower from the existing dams and supporting structures as described in Chapter 3; there are no proposed renewable energy projects within the counties representing the WRB. These future actions would contribute only background noise levels if such actions were to occur within an audible range of the project locations.

Overall, the noise environment at project locations already includes a mixture of natural and urban sound and noise sources, due to the longevity of existing USACE infrastructure. Therefore, when considered jointly with the construction of WTC towers, downstream passage structures, Pacific lamprey structures, and AFFs, applicable cumulative actions would create adverse, additive, and moderate cumulative effects from noise.

#### *4.23.2.2 Court-Ordered Design and Construction at Three Project Sites*

As discussed in Section 4.2.2, a court-ordered interim injunction has been issued that may lead to design and construction actions at the Dexter, Big Cliff, and Cougar project sites. The specific actions that could contribute to cumulative noise effects include upgrades to the existing Dexter adult fish facility (AFF), a potential structural solution at Big Cliff for mitigating excess TDG levels during spill operations, and potential structural improvements/modifications made to Cougar Dam's ROs to ensure safer fish passage and reduce TDG levels.

Overall, the noise environment at project locations already includes a mixture of natural and urban sound and noise sources, due to the longevity of existing USACE infrastructure. Although the effects from the court-ordered construction at the three project sites is being separately assessed under NEPA, these construction activities would likely produce similar moderate effects as those from previously assessed construction activities at AFFs, TDG mitigation, and fish passages. Therefore, when considered jointly with the construction of court-ordered measures at three project sites, applicable cumulative actions would create adverse, additive, and moderate cumulative effects from noise.

### 4.23.3 Discussion of Cumulative Effects by Alternative

This section analyzes the relevant cumulative actions by alternative to determine the potential cumulative effects to noise.

#### *4.23.3.1 No Action Alternative*

The NAA would include basin-wide measures to update and maintain revetments at 88 locations along the Willamette River and its tributaries. Activities related to revetment updates and maintenance would be minor. None of the cumulative actions would have effects similar to those from updating and maintaining revetments. As such, any contribution to cumulative effects would be negligible.

#### *4.23.3.2 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Under Alternative 1, three WTC towers, seven total dissolved gas improvements, one upstream or downstream passage restoration, four downstream passage structures, two Pacific lamprey passages, and two AFFs would be constructed, affecting eight project locations at Fern Ridge, Dexter, Detroit, Green Peter, Cougar, Lookout Point, Big Cliff, and Foster Dams.

As discussed above in Sections 4.23.2.1 and 4.23.2.2, these measures would have adverse, additive, and moderate cumulative effects. Any new structures under Alternative 1 would represent a relatively small contribution to the overall cumulative effects compared to all cumulative actions and within the WVS area as a whole.

#### *4.23.3.3 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Under Alternative 2A, one WTC tower, four downstream passage structures, three Pacific lamprey structures, and one AFF would be permanently built, affecting six project locations at Dexter, Detroit, Green Peter, Lookout Point, Foster, and Cougar Dams.

As discussed above in Sections 4.23.2.1 and 4.23.2.2, these measures would have adverse, additive, and moderate cumulative effects. However, any new structures under Alternative 2A would represent a small contribution to overall cumulative effects from noise when compared to all past, present, and reasonably foreseeable actions and within the WVS area as a whole.

#### *4.23.3.4 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Under Alternative 2B, the cumulative effects from noise would be the same as those described under Alternative 2A. Under this alternative, one fewer downstream passage structure would be built. As discussed above in Sections 4.23.2.1 and 4.23.2.2, these measures would contribute adverse, additive, and moderate cumulative effects. However, as with Alternative 2A, any new structures under Alternative 2B would represent a small contribution to overall cumulative effects from noise when compared to all past, present, and reasonably foreseeable actions and within the WRB area as a whole.

#### *4.23.3.5 Alternative 3A – Operations-Focused Fish Passage Alternative*

Under Alternative 3A, three AFFs and four Pacific lamprey passages would be constructed, affecting five project locations at Detroit, Green Peter, Cougar, Hills Creek, and Blue River Dams. As discussed above in Sections 4.23.2.1 and 4.23.2.2, these measures would have adverse, additive, and moderate cumulative effects. However, as with Alternative 2A and 2B, any new structures under Alternative 3A would represent a small contribution to overall cumulative effects from noise when compared to all past, present, and reasonably foreseeable actions and within the WRB area as a whole.

#### *4.23.3.6 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)*

Under Alternative 3B, the cumulative effects from noise would be the same as those described under Alternative 3A. As discussed above in Sections 4.23.2.1 and 4.23.2.2, these measures would contribute adverse, additive, and moderate cumulative effects. However, as with Alternative 2A, 2B, and 3A, any new structures under Alternative 3B would represent a small contribution to overall cumulative effects from noise when compared to all past, present, and reasonably foreseeable actions and within the WRB area as a whole.

#### *4.23.3.7 Alternative 4 – Structures-Based Fish Passage Alternative*

Under Alternative 4, the cumulative effects from noise would be the same as those described under Alternative 1. Under this alternative, one additional downstream passage structure and one additional Pacific lamprey passage structure would be constructed, affecting a total of eight projects. As discussed above in Sections 4.23.2.1 and 4.23.2.2, these measures would contribute adverse, additive, and moderate cumulative effects. As with Alternative 1, any new structures under Alternative 4 would represent a small contribution to the overall cumulative effects compared to all cumulative actions and within the WRB area as a whole.

#### *4.23.3.8 Alternative 5 - Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Under Alternative 5, the cumulative effects from noise would be about the same as those described under Alternatives 2A and 2B. Under this alternative, one fewer downstream passage structure would be built. As discussed above in Sections 4.23.2.1 and 4.23.2.2, these measures would contribute adverse, additive, and moderate cumulative effects. However, as with Alternatives 2A and 2B, any new structures under Alternative 5 would represent a small contribution to overall cumulative effects from noise when compared to all past, present, and reasonably foreseeable actions and within the WRB area as a whole.

### 4.23.4 Summary

In summary, the cumulative effects of each of the alternatives would have similar adverse, additive, and moderate effects. However, Alternative 4 has greater additive effects than Alternatives 1, 2A, 2B, 3A, 3B, and 5 because of the relatively greater number of noise-generating structural measures.

## 4.24 TRIBAL RESOURCES

### 4.24.1 Cumulative Effects Analysis Methodology for Tribal Resources

This section briefly summarizes results from the cumulative effects sections for Water Quality (Section 4.5), Fish, Aquatic Invertebrates, and Habitat (Section 4.8), Wildlife, Birds, and Terrestrial Habitat (Section 4.9), and Cultural Resources (Section 4.21). These sections were selected to reflect the primary interests and concerns outlined by local tribes as discussed in Tribal Resources (Section 3.24). Refer to the cumulative effects sections in Chapter 4 for full consideration of impacts to these four resource types and to all resources considered in this PEIS.

#### *4.24.1.1 Cumulative Actions Applicable to Tribal Resources*

Table 4.24-1 lists by resource type all past, present, and Reasonably Foreseeable Future Actions (RFFAs) that, when considered together with the Proposed Action and alternatives, would have cumulative effects on Tribal Resources.

**Table 4.24-4.24-1. List of Past Actions, Present Actions, and RFFAs Relevant to Tribal Resources**

| Action | Water Quality | Fish, Aquatic Invertebrates and Habitat | Wildlife, Birds, and Terrestrial Habitat | Cultural Resources |
|---|---|---|---|---|
| Construction and past operations of WVS dams and reservoirs | X | X | X | X |
| Ongoing operations of WVS dams and reservoirs | X | X | X | X |
| RFFA 1: Future population growth and accompanying urban, industrial, and commercial development | X | X | X | X |
| RFFA 2 - Future agricultural development | X | X | X | |
| RFFA 3 - Water withdrawals for municipal, industrial, and agricultural uses | X | X | X | |
| RFFA 4 - Decarbonizing the energy sector with renewable energy sources | X | X | X | |
| RFFA 5: Federal and state wildlife and lands management. | X | X | X | X |

| Action | Water Quality | Fish, Aquatic Invertebrates and Habitat | Wildlife, Birds, and Terrestrial Habitat | Cultural Resources |
|---|---|---|---|---|
| RFFA 6 – Fisheries management and killer whales | | X | X | |
| RFFA 7: Tribal, state, and local fish and wildlife improvement | X | X | X | X |
| RFFA 8 – Invasive species management | X | X | X | |
| RFFA 9: Climate change. | X | X | X | X |
| RFFA 10: Mining operations. | X | | X | X |
| RFFA 11: Timber and logging industry operations. | | | X | X |

The actions that are not marked with an "X" in Table 4.24-1 would not change effects on the various resources and as such would not have a cumulative effect on them. For water quality, this includes RFFAs 6 (fisheries management and killer whales) and 11 (timber and logging industry operations). For fisheries this includes RFFAs 10 (mining operations) and 11 (timber and logging industry operations). For cultural resources, this includes RFFAs 2 (future agricultural development), 3 (water withdrawals), 6 (fisheries management and killer whales), and 8 (invasive species management). These RFFAs would not affect water quality and cultural resources because they are actions that tend to occur away from the WVS. For fisheries, these actions would occur on a localized and small-scale level and affect a very small area of the WRB. As a result, the RFFAs would not directly or greatly impact fisheries of the WVS and WRB. All of the RFFAs, however, are anticipated to have cumulative effects to WRB wildlife, birds, and terrestrial habitat.

### 4.24.2 Cumulative Effects to Tribal Resources by Alternative

Construction of the Willamette Valley dams and reservoirs has greatly changed and adversely affected tribal resources in the WVS including water quality, fisheries, wildlife, birds, and terrestrial habitat, and cultural resources. On-going operations of the WVS continues to adversely affect these resources. For cultural resources these changes are irreversible. See Table 4.24-2 for a description of past and present actions that have cumulative impact to Tribal Resources.

**Table 4.2424-2. Summary of Past and Present Actions Relevant to Tribal Resources**

| Action | Description | Cumulative Impact Description |
|---|---|---|
| Past | WVS Dams and Reservoirs: construction and past operations and maintenance | Water Quality – Changed downstream water temperatures to be unnaturally cool in the summer and warm in the winter. As water is released over the spillway this creates Total Dissolved Gas (TDG) which can be detrimental to aquatic species. Increased turbidity levels typically occur due to drawdown operations of the reservoir or high flow events due to precipitation. During construction of the WVS, contaminants may have been introduced which may require removal.<br><br>Fisheries - Once the Willamette System was implemented, the floodplain became more channelized, water quality began to improve, urbanization increased, and migratory fish were excluded from a large proportion of spawning habitat in the upper Willamette tributaries. Downstream fish populations were affected by regulated flows.<br><br>Wildlife, Birds, and Terrestrial Habitat - Wildlife species and wildlife habitat within the WRB has been affected by the construction and operation of the WVS dams and reservoirs, dams constructed by other entities (Section 4.1.2.1.1), urban and rural development and land use, transportation infrastructure development, dredging and sediment management and other land-altering activities. The cumulative effect is a decrease of biodiversity and changes to a variety of habitats that support a wide range of wildlife species. Simplification of the stream channels within the WVS limits habitat availability across the floodplains that support aquatic species while also extending upland habitat for terrestrial species that would not otherwise be available.<br><br>Cultural Resources - Activities related to construction and the 50-80 years of fill and drawdown cycle of the reservoir resulted in additive, major, and adverse effects to archaeological sites through disturbance, erosion, and exposure, and traditional cultural properties through reduced and restricted access to tribal members and actions that have impacted habitat and water quality as well as destruction of archaeological sites that are part of traditional cultural properties. It also resulted in the construction of the WVS which is composed of 13 historic districts. Management and operations have been mostly beneficial through retainment of historic fabric of the 13 historic districts. Some modification or removal of some contributing resources in the past have had minor adverse cumulative effects. |

| Action | Description | Cumulative Impact Description |
|---|---|---|
| Present | WVS Dams and Reservoirs: ongoing operations and maintenance | Water Quality – see Past Action, above.<br><br>Fisheries – The present actions are characterized by continued decline of salmon and steelhead populations and a decrease in life history diversity due to limited juvenile outmigration opportunities for those spawned above dams. The hatchery program has had negative impacts on natural origin fish. The introduction of hatchery non-native summer steelhead has negatively impacted winter steelhead through genetic influence and competition.<br><br>Wildlife, Birds, and Terrestrial Habitat – see Past Action, above.<br><br>Cultural Resources - Continued draft and fill cycle is an irreversible, additive, and incremental adverse cumulative effect to archaeological sites due to active erosion and exposure. Actions that support improved habitat and water quality would have beneficial impacts to traditional cultural properties. The continued existence of the WVS restricts and reduces tribal access to traditional cultural properties which is a major adverse cumulative impact that is potentially reversible. Current operations to not include additions or modifications to the historic built environment, which is a beneficial cumulative effect. |

For water quality, fisheries, and birds and other wildlife, population growth (RFFA 1) and water withdrawals (RFFA 3), would have adverse effects through increased water temperature and pollutants introduced into the watershed. These impacts would change and reduce prime aquatic habitat that fish, birds, and other wildlife require to maintain thriving populations. While increased agricultural development (RFFA 2) could do the same, review of human use trends in the Willamette Valley suggest that cropland development will continue to decrease, which would benefit water quality due to a decrease in water demand and pollutants, which would in turn benefit fish habitat. Wildlife and birds would still be adversely affected by this generalized activity and by the continued fragmented habitat and passage that occurs due to developed land bases (whether agricultural or other). Decarbonizing the energy sector for renewable energy sources (RFFA 4), could improve or harm water quality through changes in TDG levels which would directly affect fish habitat, but other wildlife and birds would still face adverse disruption due to fragmented habitat and passage as renewable energy projects occur throughout the WRB. Population growth and general development in the Willamette Valley (RFFA 1) would have adverse effects to cultural resources due to increased visitor access to the WVS reservoirs and associated recreation areas. This access would increase looting of archaeological sites and increase degradation of historic structures that are part of recreation sites. The increase in visitors will also increase competition for access and resources that are important to tribal communities including those associated with traditional cultural properties.

State, tribal, and federal management strategies that are conservation or restoration-focused as well as management of invasive species (RFFAs 5, 7, and 8) are likely to provide benefits to improved water quality, fisheries, and other wildlife and birds. These efforts would focus on habitat restoration and the reduction of oxygen-depleting invasive plants. However, some management actions could be detrimental if they are focused on resource development or extraction, which would continue to fragment and degrade animal habitat and passage. These actions could similarly benefit cultural resources if the actions are focused on restoring resources and access to traditional cultural landscapes, but they could also prove to be detrimental if the actions are meant to draw visitors to locations where vulnerable archaeological sites are present.

Climate change (RFFA 9) is anticipated to adversely affect all tribal resources including water quality, fisheries, wildlife, birds, and terrestrial habitat, and cultural resources due to extreme changes in environmental conditions that reduce water, increase water temperatures, increase exposure of reservoir beds and associated archaeological sites, modify and fragment prime habitat for fish wildlife, and birds, cut off access to lands and resources important to tribal communities, etc.

Mining operations (RFFA 10) and timber and logging industry operations (RFFA 11) have the potential to negatively affect water quality through the introduction of contaminants into the Willamette Valley watershed, but these actions are localized and increasingly uncommon in the Willamette Valley. Cultural resources are directly affected at these locations by ground disturbance and later erosion of surrounding landforms. Birds and other wildlife are impacted by fragmented habitat and passage, as well as noise and human interaction during breeding periods that reduce species productiveness and ability to nurse young into adulthood.

Potential effects to tribal resources are listed by RFFA in Table 4.24-3.

**Table 4.2424-3. Summary of Reasonably Foreseeable Future Actions (RFFA) Relevant to Tribal Resources**

| RFFA # | RFFA Description | Cumulative Impact Description |
|---|---|---|
| RFFA 1 | Future population growth and urban, industrial, and commercial development | Water Quality - There may be adverse effects from increased water demand which cause an increase of instream water temperatures and pollution due to increased stormwater runoff from these sectors.<br><br>Fisheries - Increased runoff leading to non-point source pollutants affecting fish health, behavior and survival; increased winter flows leading to increased off-channel or floodplain habitat for rearing fish; increased summer water temperatures where withdrawals decrease instream flow leading to changes in fish habitat availability, particularly in the mainstem Willamette River. |

| RFFA # | RFFA Description | Cumulative Impact Description |
|---|---|---|
| | | Wildlife, Birds, and Terrestrial Habitat – Continue to affect wildlife species by disturbing individuals and further fragmenting habitat during construction activities.<br><br>Cultural Resources - Adverse effect to archaeological sites due to increased looting, traditional cultural properties through competition for access and resources important to Indian tribes and built resources that experience degradation due to increased visitor use. |
| RFFA 2 | Future agricultural development | Water Quality - Potential beneficial effect to water quality due to decrease in cropland and water demand.<br><br>Fisheries - Conversion/development of croplands will decrease water demand and water pollutants from croplands, improving aquatic habitat for fish.<br><br>Wildlife, Birds, and Terrestrial Habitat - Would further fragment wildlife habitat and passage within these areas. Fence installation, grazing livestock, and cultivating crops with machinery would affect wildlife by limiting passage through these areas. Spreading invasive plant species from these areas can affect downstream riparian habitat. |
| RFFA 3 | Water withdrawals for municipal, industrial, and agricultural uses | Water Quality - An increase in water withdrawals may cause adverse effects for instream water temperatures.<br><br>Fisheries - Increased water demands, particularly below Salem, leading to increased water temperatures, pollutant concentrations, and change aquatic habitat availability. Limited negative effect on ESA-listed fish expected (spring Chinook, winter steelhead and bull trout) since very few adults or juveniles are present in the mainstem during summer months, and some positive effects may occur within tributaries from increasing stored water releases from WVS reservoirs on tributaries to meet new water withdrawals on the mainstem.<br><br>Wildlife, Birds, and Terrestrial Habitat - Would have the effect of either decreasing reservoir water surface elevation, decreasing instream flows, or a combination of both. Decreased water surface elevation would affect aquatic species such as breeding amphibians and reptiles that depend on inundation at certain times of year for reproductive success. Many aquatic wildlife species also depend on wetland habitat that would be affected by decreasing water surface elevations. |
| RFFA 4 | Decarbonizing the energy sector with | Water Quality – Possible adverse effects due to potential increase in lack-of-market/lack-of-turbine capacity spill, which |

| RFFA # | RFFA Description | Cumulative Impact Description |
|---|---|---|
| | renewable energy sources | may lead to higher TDG levels. Decarbonizing and utilizing electrical transportation may reduce involuntary spill from lack-of-market spill<br><br>Fisheries - If the demand for hydropower generation decreases, this could benefit fish and aquatic habitat downstream by increasing operational flexibility of WVS dams and reservoirs to meet non-hydropower missions, included those for fish passage and water temperature. Conversely if the demand for hydropower increases leading to increased power peaking operations or use of turbines at WVS dams, then these changes could decrease fish passage rates or survival and could affect water temperature management.<br><br>Wildlife, Birds, and Terrestrial Habitat - Continue to affect wildlife species by disturbing individuals and further fragmenting habitat during construction activities. |
| RFFA 5 | Federal and State Wildlife and Lands Management | Water Quality - Potential beneficial effect to water quality due to habitat restoration and land use management.<br><br>Wildlife, Birds, and Terrestrial Habitat – Would continue to affect wildlife and wildlife habitat by disturbing individuals, particularly during breeding periods, and fragmenting habitat.<br><br>Cultural Resources - Varies, could be beneficial or adverse depending on management action. |
| RFFA 6 | Fisheries Management and Killer Whales | Fisheries - If the demand for hydropower generation decreases, this could benefit fish and aquatic habitat downstream by increasing operational flexibility of WVS dams and reservoirs to meet non-hydropower missions, included those for fish passage and water temperature. Conversely if the demand for hydropower increases leading to increased power peaking operations or use of turbines at WVS dams, then these changes could decrease fish passage rates or survival and could affect water temperature management.<br><br>Wildlife, Birds, and Terrestrial Habitat - Would continue to affect wildlife and wildlife habitat by disturbing individuals, particularly during breeding periods, and fragmenting habitat. |
| RFFA 7 | Tribal, State, and local fish and wildlife improvement | Water Quality - Potential beneficial effect to water quality due to habitat restoration and land use management.<br><br>Wildlife, Birds, and Terrestrial Habitat – Includes river and floodplain restoration actions and potentially environmental flows to inundate floodplain areas. These floodplain |

| RFFA # | RFFA Description | Cumulative Impact Description |
|---|---|---|
| | | restoration actions would sometimes involve some consideration of wildlife effects and improvement of wildlife habitat.<br><br>Cultural Resources - Varies, could be beneficial or adverse depending on improvement action. |
| RFFA 8 | Invasives Species Management | Water Quality - Potential benefit in removal of oxygen depleting plant species. An adverse effect if chemicals are utilized for removal management.<br><br>Wildlife, Birds, and Terrestrial Habitat - Range of management actions taken by federal, state, and local agencies as well as private organizations to combat the spread of invasive species, including invasive wildlife species. In addition, management of invasive plants can help by protecting wildlife habitat, like wetlands, where the ecological functions of the habitat would change with invasive plant infestation. |
| RFFA 9 | Climate change | Water Quality - Potential adverse effects from increased air temperature may result in increased water temperatures. There is potential for higher winter water volumes and lower summer water volumes. Potential increased water volumes may necessitate increase spill causing elevated TDG levels. A decrease in flow and water volumes in the summer may cause elevated instream water temperatures.<br><br>Wildlife, Birds, and Terrestrial Habitat - Would affect wildlife and wildlife habitat primarily due to longer drier summers. Habitat that occurs in riparian areas, such as wetland and aquatic habitat, would shrink and the ecological functions would change and less able to support certain aquatic species. Water temperature would increase with climate change, which would affect fish and other forage species that wildlife species depend on. With increased water temperature there would be an increase in toxic algal blooms, which can adversely affect wildlife species and food chains. The seasonality of wildlife species (e.g., birds, reptiles, insects, etc.) life histories would need to adjust to the new climate patterns, which would have a number of adverse effects to species, interactions between species, and interactions with their habitats.<br><br>Cultural Resources - Adverse effect due to increased winter precipitation that erodes archaeological sites, reduced water levels in the summer that expose archaeological sites, both would increase looting and vandalism to archaeological sites. Adverse effect to traditional cultural properties through reduced/degraded water quality and habitat of species |

| RFFA # | RFFA Description | Cumulative Impact Description |
|---|---|---|
| | | important to Indian tribes. Wildfire would negatively affect all types of cultural resources. |
| RFFA 10 | Mining operations | Water Quality - Potential adverse effects due to contaminants entering waters via runoff.<br>Wildlife, Birds, and Terrestrial Habitat - Would continue to affect wildlife and wildlife habitat by disturbing individuals, particularly during breeding periods, and fragmenting habitat.<br><br>Cultural Resources - Localized to mining operation, direct adverse effects to archaeological sites (erosion) and traditional cultural properties downstream habitat and water quality degradation), but unlikely to affect built resources. |
| RFFA 11 | Timber and logging industry operations | Wildlife, Birds, and Terrestrial Habitat – Would continue to affect wildlife and wildlife habitat by disturbing individuals, particularly during breeding periods, and fragmenting habitat.<br><br>Cultural Resources - Direct effects localized to logging unit, where ground disturbance can negatively affect archaeological sites, but indirect effects could negatively affect viewshed of 13 historic districts (built resources) and traditional cultural properties on decadal scale. Indirect effects would be temporary. |

General trends in this section apply to water quality, fisheries, birds and other wildlife, and cultural resources across alternatives. The following sections briefly summarize the broad aspects of cumulative effects to tribal resources by the four resource types for each alternative (water quality, fisheries, birds and other wildlife, and cultural resources). Please refer to sections 4.5 (water quality), 4.8 (fisheries, aquatic invertebrates, and habitat), 4.9 (wildlife, bird, and terrestrial habitat), and 4.21 (cultural resources) for discussion of detailed resource specific cumulative impacts.

#### *4.24.2.1 No Action Alternative*

Within the WVS quality parameters include water temperature, TDG, Turbidity, HABs, and Mercury (Coast Fork Willamette). Under the NAA, the RFFA including climate change has the greatest potential to alter these water quality parameters. Population growth along with municipal and industrial has the potential to increase instream water demand and stormwater run-off pollution. An increase of TDG exceedances may occur with decarbonizing the energy sector and lack of turbine capacity spill for hydropower generation. Non-point and point source pollution occurrence may increase due to mining operations and population growth.

Negative impacts to fisheries from the RFFAs include those from increased winter runoff, increased water temperatures from water withdrawals, and non-point source pollutants from population growth and development degrading aquatic habitat conditions and reducing fish health and survival. Water withdrawals for municipal and industrial (M&I) uses will also decease flows downstream of Salem, however since very few are present in the mainstem during summer months, limited negative effects on ESA-listed fish (spring Chinook, winter steelhead and bull trout) are expected from these M&I withdrawals. Effects of decarbonizing the energy sector with renewable energy sources is difficult to predict, however if the demand for hydropower increases leading to increased power peaking operations or use of turbines at WVS dams, then these changes could decrease fish passage rates or survival and could affect water temperature management. Increased negative effects from invasive species on native fish (primarily competition and predation) is also expected to increase, in particular due to climate change effects favoring invasive species.

Some positive effects of RFFAs on fish and aquatic habitat in the WRB can also be expected. Conversion/development of croplands will decrease water demand and water pollutants, improving aquatic habitat conditions for fish. If the demand for hydropower generation decreases, this could benefit fish and aquatic habitat downstream by increasing operational flexibility of WVS dams and reservoirs to meet non-hydropower missions, included those for fish passage and water temperature. Fishing performance in the future would be at least as variable as it is at present due to variability in ocean conditions and fish survival in the ocean, and changes in salmon hatchery production. Ongoing and future aquatic and riparian habitat restoration and mitigation actions would also be expected to directly and indirectly have positive impacts on fish.

RFFAs are expected to infer a net negative impact in addition to the effects accounted for in the fisheries environmental consequences section. Poor fish passage conditions at WVS dams will continue to significantly constrain population viability of ESA-listed salmon and steelhead, and effects of RFFAs on habitat conditions below dams will further reduce population viability. Similarly, RFFAs also will infer a net negative impact for bull trout, stemming primarily from climate change-related contraction of existing habitat occupied above WVS dams (increased winter flows, decreased summer low flows, increased water temperatures) in high elevation areas. Under the NAA, bull trout do not have effective access to below dam habitat, however stream reaches below dams will further degraded in the future and not be expected to provide any suitable spawning areas, experience a reduction and degradation in available rearing habitat, and survival rates of bull trout below dams would be expected to decline due to increases in recognized risk factors

Combined with the cumulative effects listed above (particularly climate change), there would likely be additional impacts to wildlife and wildlife habitat under the NAA. As discussed in section 3.9.2.2, the effects of the No Action Alternative would have both a beneficial and an adverse effect to wildlife and wildlife habitat in the WVS. The beneficial effect of the NAA is that water storage in the reservoirs would be maintained and would continue to support hydrology in aquatic and wetland habitats at the reservoirs that may not otherwise exist. One adverse effect is that since stream flows would continue to be managed for flood control and confined to a fairly uniform channel, wildlife habitat along reaches downstream of the USACE projects would continue to be limited in diversity and amount available. In addition, without fish passage provided, forage species (including but not limited to salmonids) population size would be limited upstream of the WVS projects. The NAA on its own would have both minor beneficial and adverse effects to wildlife and wildlife habitat, maintaining existing conditions. Combined with cumulative effects (primarily climate change), there would be major adverse effects to wildlife within the WVS in the form of changes to suitable habitat acreage, water quality, and the seasonality of wildlife life histories.

The NAA maintains an annual draft and fill cycle that has major direct irreversible adverse effects to 80% of archaeological sites documented in the WVS, as discussed in section 3.21. This draft and fill erodes archaeological sites that overlap with the reservoirs and exposes these sites to illicit collection and other human-caused damage. Population growth and climate change would have additive, major, and adverse effects to archaeological sites. Archaeological sites in the WVS have already experienced major irreversible impacts from the construction of the WVS dams and reservoirs and have experienced five to eight decades of draft and fill cycles. Increased recreation at the WVS will further exacerbate looting and illicit collection that degrades the integrity of archaeological sites. Climate change that results in increased erosion of reservoir beds in the winter and increased exposure of reservoir beds in the spring and summer will have similar impacts. The deep drawdowns at Fall Creek continue to increase the erosion and exposure of archaeological sites present at this reservoir.

Traditional cultural properties are not well documented in the WVS, but it is assumed that they are present given the lengthy habitation of the Willamette Valley by indigenous communities as discussed in section 3.21. The construction and continued operation of the WVS has had major direct adverse effects to traditional cultural properties including archaeological sites, habitat, and water quality as well as reduced and restricted access to the lands that now comprise the WVS. The cumulative effects of past and present actions and population growth are major and adverse. There is potential to reverse some of these negative effect through management actions that improve habitat, water quality, and access to them by tribal communities. Potentially, RFFAs 5 and 7 (management by various entities) would have beneficial effects to traditional cultural properties, but with population growth and climate change tribal communities may be forced to compete for access and resources as more people move into the Willamette Valley. The archaeological components of traditional cultural properties cannot be rehabilitated, but increased access by tribal members would provide a beneficial cumulative effect. RFFA 10 (mining operations) and 11 (timber and logging industry operations), which would adversely impact the viewsheds of traditional cultural properties, have the potential to cause minor to moderate cumulative impacts. The existence of the WVS has already significantly directly and indirectly impacted traditional cultural properties in the six sub-basins, so continued resource extraction would not greatly increase the negative effects.

No new construction or modification to the 13 historic districts is considered under the NAA, but increased visitor use, and resource extraction (RFFA 10 and 11) have the potential to directly and indirectly impact historic recreation sites that are present in the WVS. Over time, this could result in minor to moderate adverse cumulative effects, but these could be minimized or reversed through maintenance plans and recreation management plans that prioritize maintaining the historic aesthetic and viewshed of the WVS.

#### *4.24.2.2 Alternative 1 – Improve Fish Passage Through Storage-Focused Measures*

Compared to the NAA, Alternative 1 would result in minor to major beneficial water temperature effects in the Middle Fork Willamette, South Santiam, and North Santiam basins due to the proposed temperature control structures at Lookout Point, Green Peter, Detroit Dams. Minor to major beneficial TDG effects are expected in the North Santiam and South Fork McKenzie basins based on the reduced number of spill days and proposed TDG abatement structures in Alternative 1. Cumulative effects from the RFFAs have the potential to modify water temperature, turbidity, HABs, and mercury in some of the WVS watersheds. In general, the cumulative effects from the RFFAs would result in negligible adverse effects or may increase negative effects to an unknown degree.

Alternative 1 implementation is predicted to have major impacts on Chinook salmon and minor adverse impacts on winter steelhead in the North and South Santiam. Lifecycle models predict a high risk of extinction in the McKenzie and Middle Fork. The downstream passage structure at Lookout Point is dependent on the dam operations and predicted to perform poorly likely due to the storage theme of Alternative 1. Scores and risks for bull trout would be ranked similar to the No Action Alternative, with minor effects predicted. Habitat scoring for bull trout is only marginally better than in the No Action Alternative with rearing/forage habitat increases for North Santiam bull trout below Detroit. Increased municipal water demand would likely compete with endangered fish and aquatic species needs such that stored water would likely need to be prioritized among interests. Federal and state land management downstream of project may be directly impacted by water storage practices, however, conservation efforts above project where the majority of quality habitat for endangered fish is expected to be, would likely be improved under Alternative 1. With respect to climate change, water storage is likely to be a more resilient planning strategy due to the fact that precipitation patterns and snow pack are expected to be more variable and less predictable. Overall, while Alternative 1 may not perform the best over other alternatives, with regard to fisheries. However, it does provide some resiliency for fish and wildlife given the uncertainties with respect to urbanization, land use, climate change, and water use needs predicted in the future.

Overall, cumulative effects to wildlife and wildlife habitat would be anticipated to be major over the period of analysis. However, Alternative 1 would not contribute substantially to the changes to wildlife and wildlife habitat within the WVS. Changes to biodiversity and suitable habitat availability would be affected to a greater magnitude by climate change, water withdrawals, and habitat fragmentation due to development than by Alternative 1.

Alternative 1 combined with past, present, and reasonably foreseeable actions would have similar direct, indirect, and cumulative effects to archaeological sites and traditional cultural properties as the NAA. For archaeological sites, the cumulative effects are major, additive, irreversible, and adverse. For traditional cultural properties, the cumulative effects vary from beneficial to adverse, but most are potentially reversible with the exception of the destruction of archaeological sites that may be part of traditional cultural properties. Alternative 1 deviates from the NAA in the management of built resources, which includes structural modifications to seven of the historic districts and would have moderate to major direct effects. Overall, the cumulative effects do not greatly increase adverse effects or create beneficial effects beyond what is discussed in section 3.21.

#### *4.24.2.3 Alternative 2A – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Compared to the NAA, Alternative 2A resulted in minor to major beneficial water temperature effects in the North and South Santiam sub-basins due to the proposed temperature control structure at Detroit dam and the Green Peter deep autumn drawdown. Minor to moderate beneficial TDG effects are expected in the North Santiam due to the proposed temperature control structure at Detroit that removes the need for operational temperature control with non-turbine outlets. Moderate to major adverse TDG effects are expected in the South Santiam due to the Green Peter deep autumn drawdown that relies on more spill flow in in Alternative 2A. Cumulative effects from the RFFAs have the potential to modify water temperature, turbidity, HABs, and mercury in some of the WVS watersheds. In general, the cumulative effects from the RFFAs would result in negligible adverse effects or may increase negative effects to an unknown degree.

Alternative 2A would have moderate adverse effects on Chinook salmon, predicted to produce the most viable populations compared to other alternatives and retains the McKenzie core legacy population. For Chinook and steelhead, there was agreement in most cases found from assessing population performance with lifecycle models, except for the South Santiam. Alternative 2A produces the most optimistic outcomes for Chinook salmon in the Middle Fork among the alternatives, accomplished with a downstream passage structure at Lookout Point exclusive of passage at Hills Creek. Alternative 2A would have minor adverse impacts to Santiam winter steelhead populations. Bull trout habitat scores and risks are comparable to Alternative 1, with a fish passage addition providing access to habitat below Cougar Dam. Alternative 2A would have minor adverse impacts for bull trout. Structural improvements for fish passage and water temperature provide resilience to climate change by increasing operational flexibility in the North Santiam, South Santiam, and Middle Fork sub-basins. Given the uncertainty of water availability in the future and the expected increase in wildfire frequency with ongoing climate change, the ability to store more water earlier in the year may become a very valuable resiliency strategy. However, the reservoir drawdown to the regulating outlet at Cougar Dam in spring proposed at Cougar Dam for downstream fish passage will eliminate much of the ability to store water in Cougar Reservoir specifically.

Agricultural demand will likely decrease over time as use shifts to urban expansion and municipal uses. Water withdrawals are expected to increase which will impact endangered fish and aquatic species below project negatively. Demand for hydropower may increase which will likely show positive responses for endangered fish and aquatic species where at-dam/turbine friendly solutions are prioritized, a slightly positive effect on endangered fish and aquatic species where operational downstream passage is prioritized, and a detrimental effect from decarbonization leads to increased hydropower operations where operational downstream fish passage is prioritized. Federal and state wildlife and land management would likely be less affected in terms of direct and indirect effects. Where there are opportunities for storage at large projects such as Detroit where water availability would be more variable, agencies could incorporate adaptive planning. Tribal, state, and local wildlife management would likely reflect outcomes described under Alternative 1. Invasive species management would likely be complicated by the combination of at-dam storage and operational downstream passage approaches. This could result in management plans that are more reactive given that such operations have not yet been observed and monitored.

Overall, cumulative effects to wildlife and wildlife habitat would be major over the period of analysis. Changes to wildlife and wildlife habitat in terms of biodiversity and suitable habitat availability would be affected by climate change, water withdrawals, and habitat fragmentation due to development. Alternative 2A would also have moderate effects to wildlife and wildlife habitat within the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in most subbasins.

Like the NAA and Alterative 1, Alternative 2A has major direct irreversible adverse effects to archaeological resources. Alternative 2A proposes a deep fall drawdown at Green Peter and Fall Creek as opposed to just Fall Creek (with the NAA and Alternative 1). This would increase negative erosion and exposure of archaeological sites that will occur at two reservoirs. Similar to the NAA and Alternative 1, the cumulative effects of past, present, and reasonably foreseeable actions combined with Alternative 2A will be additive, major, and adverse to archaeological sites. Traditional cultural properties would have similar and varying cumulative impacts as described in the NAA and Alternative 1 sections. Built resource cumulative impacts would be similar to those described for Alternative 1 but occur at six projects (rather than seven as in Alternative 1). Overall, the cumulative effects do not greatly increase adverse effects or create beneficial effects beyond what is discussed in section 3.21.

#### *4.24.2.4 Alternative 2B – Integrated Water Management Flexibility and ESA-Listed Fish Alternative*

Compared to NAA, Alternative 2B resulted in minor to major beneficial water temperature effects in the North Santiam, South Santiam, and South Fork McKenzie sub-basins due to the proposed temperature control structure at Detroit dam, Green Peter deep autumn drawdown with operational temperature control, and a deep drawdown at Cougar. Minor to moderate beneficial TDG effects are expected in the North Santiam and South Fork McKenzie sub-basins due to a reduced number of days with spill (at Detroit, the proposed temperature control structure removed the need for operational temperature control with non-turbine outlets). Minor beneficial TDG effects are expected in the South Fork McKenzie sub-basin under Alternative 2B due to the deep drawdown at Cougar that involves use of the diversion tunnel, which is expected to have lower TDG than the regulating outlet. Moderate to major adverse TDG effects are expected in the South Santiam due to the Green Peter deep autumn drawdown that relies on more spill flow in Alternative 2A. Cumulative effects from the RFFAs have the potential to modify water temperature, turbidity, HABs, and mercury in some of the WVS watersheds. In general, the cumulative effects from the RFFAs would result in negligible adverse effects or may increase negative effects to an unknown degree.

The only difference between Alternative 2A and Alternative 2B is that 2B has an operational downstream fish passage measure at Cougar Dam (deep drawdown to near the diversion tunnel in spring and fall) instead of a structural measure. Operational fish passage at Cougar Dam proposed for this Alternative is estimated to be more effective that that proposed for Alternative 2A at Cougar Dam. Future population growth under this alternative will likely have lesser impact to endangered fish and aquatic species due to implementation at projects where storage is prioritized over operational passage. Under Alternative 2B, an at-dam structure proposed for Detroit and Lookout Point dams promote storage, integration with hydropower, and downstream water uses nearest communities that are expected to increase in population and likely water demand downstream. Operational downstream passage is proposed at Green Peter and Cougar dams where urbanization downstream is unlikely to increase and effects on the public are expected to be less impactful. Minimum flow targets proposed are responsive to water storage availability in the spring. Minimum flows for fish as included are designed to adjust with real-time water availability, supporting downstream fish passage measures, and habitat and water temperature needs for fish below dams. However, the reservoir drawdown to the regulating outlet at Cougar Dam in spring proposed at Cougar Dam for downstream fish passage will eliminate much of the ability to store water in Cougar Reservoir specifically.

Overall, cumulative effects to wildlife and wildlife habitat would be major over the period of analysis. Changes to wildlife and wildlife habitat in terms of biodiversity and suitable habitat availability would be affected by climate change, water withdrawals, and habitat fragmentation due to development. Alternative 2B would also have moderate effects to wildlife and wildlife habitat within the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in most subbasins. Most notably at Cougar reservoir, because deep fall and spring drawdowns would be included as a part of Alternative 2B (as opposed to Alternative 2A) there would be potential for major effects to aquatic and wetland habitat around the reservoir when combined with climate change effects.

Like the NAA and Alterative 1, Alternative 2A follows a rule curve that results in one major cycle of draft and fill per water year, which has major direct irreversible adverse effects to archaeological resources. Alternative 2A proposes a deep fall drawdown at Green Peter (780 feet) and Fall Creek as opposed to just Fall Creek (with the NAA and Alternative 1). This is an increase in negative erosion and exposure of archaeological sites that will occur at two reservoirs. Similar to the NAA and Alternative 1, the cumulative effects of past, present, and reasonably foreseeable actions combined with Alternative 2A will be additive, major, and adverse to archaeological sites. Traditional cultural properties will be similarly cumulatively impacted as described in the NAA and Alternative 1 sections. Built resource cumulative impacts would be similar to those described for Alternative 1 and occur at the same six reservoirs listed in Alternative 2A. Overall, the cumulative effects do not greatly increase adverse effects or create beneficial effects beyond what is discussed in section 3.21.

#### *4.24.2.5 Alternative 3A – Operations-Focused Fish Passage Alternative*

Compared to NAA, Alternative 3A resulted in minor to major beneficial water temperature effects in the Middle Fork Willamette (between Hills Creek dam and Lookout Point Dam) and South Santiam sub-basins due to the proposed deep drawdowns at Hills Creek and Green Peter dams. In the North Santiam sub-basin, minor beneficial effects to water temperature are expected during the autumn while moderate adverse effects are expected during the spring-summer due to deep drawdown at Detroit Dam in Alternative 3A. In the South Fork McKenzie sub-basin, minor adverse effects to water temperature are expected during the fall due to a partial drawdown at Cougar Dam in Alternative 3A. Minor to major adverse TDG effects are expected in the North Santiam, South Santiam, and Middle Fork Willamette due to the deep drawdowns at Detroit, Green Peter (autumn) and Lookout Point that rely on higher outflows and/or spill flow in Alternative 3A. Cumulative effects from the RFFAs have the potential to modify water temperature, turbidity, HABs, and mercury in some of the WVS watersheds. In general, the cumulative effects from the RFFAs would result in negligible adverse effects or may increase negative effects to an unknown degree.

Alternative 3A is focused on operational measures at WVS dams for fish passage and water quality. Operational measures for fish passage and water quality are less resilient to changes associated with RFFAs, when compared to structural measures, since structural measures are designed to be effective at a range of reservoir pool elevations and discharge rates, whereas operational measures effectiveness varies with reservoir elevation/volume, discharge outlets available, and discharge rates. Some positive effects of RFFAs on fish and aquatic habitat in the WRB may counter-balance some of the negative effects. Conversion/development of croplands will decrease water demand and associated water pollutants. If the demand for hydropower generation decreases, this could benefit fish and aquatic habitat downstream by increasing operational flexibility of WVS dams and reservoirs to meet non-hydropower missions, included those for fish passage and water temperature. Ongoing and future aquatic and riparian habitat restoration and mitigation actions would also be expected to directly and indirectly have positive impacts on fish.

Overall, cumulative effects to wildlife and wildlife habitat would be major over the period of analysis. Changes to wildlife and wildlife habitat in terms of biodiversity and suitable habitat availability would be affected by climate change, water withdrawals, and habitat fragmentation due to development. Alternative 3A would also have moderate effects to wildlife and wildlife habitat within the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in most subbasins as discussed below.

The NAA, Alternative 1, Alternative 2A, Alternative 2B, and Alternative 3A have an annual cycle of draft and fill of the reservoirs, which have direct, irreversible, adverse effects to archaeological sites. Alternative 3 would strongly accelerate major direct adverse effects to archaeological sites with proposed deep drawdowns at six reservoirs including Blue River, Hills

Creek, Green Peter, Detroit, Lookout Point, and Cougar. Alternative 3 combined with past, present, and reasonably foreseeable actions would have the greatest adverse additive impacts to archaeological sites. Traditional cultural properties would likely have adverse cumulative effects that are greater than those described in the NAA, Alternative 1, Alternative 2A, and Alternative 2B, but this resource type is not well documented in the WVS and cannot be fully discussed other than to note that there are tradeoffs to measures that negatively affect archaeological sites that are part of traditional cultural properties but would benefit habitat and water quality. Alternative 3A would have less adverse cumulative effects to built resources than Alternative 1, Alternative 2A, and Alternative 2B, but more than the NAA. Modifications would occur at four of the historic districts. Overall, the cumulative effects do not greatly increase adverse effects or create beneficial effects beyond what is discussed in section 3.21.

#### *4.24.2.6 Alternative 3B – Operations-Focused Fish Passage Alternative (using diversion tunnel at CGR)*

Compared to NAA, Alternative 3B resulted in minor to moderate beneficial water temperature effects in the Middle Fork Willamette, McKenzie, and South Santiam sub-basins due to the proposed drawdowns at Hills Creek, Lookout Point, Cougar, and Green Peter dams. Minor to major adverse TDG effects are expected in the North Santiam, South Santiam, and Middle Fork Willamette (below Dexter Dam) due to the deep drawdowns at Detroit (autumn), Green Peter, and Lookout Point (autumn) that rely on high outflows, thereby increasing the number of days with spill in Alternative 3B. Minor beneficial TDG effects are expected in the South Fork McKenzie sub-basin under Alternative 3B due to the deep drawdown at Cougar that involves use of the diversion tunnel, which is expected to have lower TDG than the regulating outlet. Cumulative effects from the RFFAs have the potential to modify water temperature, turbidity, HABs, and mercury in some of the WVS watersheds. In general, the cumulative effects from the RFFAs would result in negligible adverse effects or may increase negative effects to an unknown degree.

Alternative 3B is also focused on operational measures at WVS dams for fish passage and water quality. As described for 3A, operational measures for fish passage and water quality are less resilient to changes associated with RFFAs, when compared to structural measures. Spring drawdowns, in particular where they occur, significantly decrease resiliency. Spring drawdowns to regulating outlets occur at Green Peter and Hills Creek, and to the diversion tunnel at Cougar Dam in Alternative 3A. Alternative 3B is very similar to 3A. The primary differences are related to locations of the drawdowns and the fact that deep drawdowns occurring at Cougar would be to the elevation of the diversion tunnel. As for Alternative 3B, some positive effects of RFFAs on fish and aquatic habitat in the WRB may counter-balance some of the negative effects. Conversion or development of croplands will decrease water demand and associated water pollutants. If the demand for hydropower generation decreases, this could benefit fish and aquatic habitat downstream by increasing operational flexibility of WVS dams and reservoirs to meet non-hydropower missions, included those for fish passage and water temperature. Ongoing and future aquatic and riparian habitat restoration and mitigation actions would also be expected to directly and indirectly have positive impacts on fish.

Overall, cumulative effects to wildlife and wildlife habitat would be major over the period of analysis. Changes to wildlife and wildlife habitat in terms of biodiversity and suitable habitat availability would be affected by climate change, water withdrawals, and habitat fragmentation due to development. Alternative 3B would also have moderate effects to wildlife and wildlife habitat within the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in most subbasins as discussed below.

Alterative 3B shares similarities with 3A, but is quite different from the NAA, Alternative 1, Alternative 2A, and Alternative 2B. Fall deep drawdowns are proposed for the same six reservoirs including Blue River, Hills Creek, Green Peter, Detroit, Lookout Point, and Cougar. Spring deep drawdowns, however, are proposed at Hills Creek, Cougar, and Green Peter. In both of these alternatives, Cougar will have a spring and fall deep drawdown. In Alternative 3B, the fall deep drawdown will pass through the diversion tunnel. Like Alternative 3A, these actions will have major irreversible direct adverse effects to archaeological sites, more so than the NAA, Alternative 1, Alternative 2A, and Alternative 2B. Severe additive and adverse cumulative impacts to archaeological sites would occur with Alternatives 3A and 3B.

There would likely be greater adverse cumulative effects to traditional cultural properties (TCPs) than those described in the NAA, Alternative 1, Alternative 2A, and Alternative 2B, and similar to those that would occur with Alternative 3A. However, this resource type is not well documented in the WVS and cannot be fully discussed other than to note that there are tradeoffs to measures that negatively affect archaeological sites that are part of traditional cultural properties but would benefit habitat and water quality. Alternative 3B would have less adverse cumulative effects to built resources than Alternative 1, Alternative 2A, and Alternative 2B, more than the NAA, and similar to Alternative 3A. Modifications would occur at the same four of the historic districts including Hills Creek, Cougar, Blue River, and Green Peter. Overall, the cumulative effects do not greatly increase adverse effects or create beneficial effects beyond what is discussed in section 3.21.

#### *4.24.2.7 Alternative 4 – Structures-Based Fish Passage Alternative*

Compared to NAA, Alternative 4 resulted in minor to major beneficial water temperature effects in the Middle Fork Willamette (between Hills Creek Dam and Lookout Point Dam), South Santiam, and North Santiam basins due to the proposed temperature control structures at Hills Creek, Lookout Point, and Detroit Dams as well as operational temperature control at Green Peter Dam. Minor to Major beneficial TDG effects are expected in the North Santiam and South Fork McKenzie sub-basins based on the proposed TDG abatement structures below Detroit and Big Cliff Dams and the reduced number of spill days at Cougar Dam in Alternative 4. Cumulative effects from the RFFAs have the potential to modify water temperature, turbidity, HABs, and mercury in some of the WVS watersheds. In general, the cumulative effects from the RFFAs would result in negligible adverse effects or may increase negative effects to an unknown degree.

Alternative 4 is a structural downstream passage themed alternative with the intent to prioritize and operate with a focus on ESA-listed fish species. Proposed downstream fish passage structures are proposed for Detroit, Foster, Cougar, Hills Creek, and Lookout Point dams. It is expected that as demand for agricultural use becomes less frequent with conversion to urban uses, negative impacts from effluent and agricultural runoff will positively affect fish and wildlife resources. Increased municipal water demand would likely compete with endangered fish and aquatic species needs. Increased urbanization expected in the future would likely mean a greater need for decarbonization and possibly greater demand for hydropower. Federal and state land management downstream of project may be directly impacted by water storage practices, however, conservation efforts above project where the majority of quality habitat for endangered fish is expected to be, would likely be improved under Alternative 4. Pacific Ocean harvest management is unlikely to be directly affected but may be indirectly affected by the percentage of hatchery fish that make up total catch. Tribal, state, and local land management may be negatively impacted downstream of project depending on the allocation and water year type experienced in any given year. With respect to climate change, water storage is likely to be a more resilient planning strategy due to the fact that precipitation patterns and snowpack are expected to be more variable (and less predictable). Alternative 4 provides some resiliency for fish and wildlife given the uncertainties with respect to urbanization, land use, climate change, and water use needs predicted in the future.

Overall, cumulative effects to wildlife and wildlife habitat would be anticipated to be major adverse over the period of analysis. However, Alternative 4 would not contribute substantially to the changes in the wildlife and wildlife habitat of the WVS. Changes to wildlife and wildlife habitat in terms of changes to biodiversity and suitable habitat availability would be affected more by climate change, water withdrawals, and habitat fragmentation due to development than by Alternative 4.

Alternative 4 proposes a WVS-wide cycle of draft and fill that would continue to directly, irreversibly, and adversely affect 369 (80%) of the archaeological sites present in the WVS. Alternative 4, however, does not propose any deep drawdowns or spring spills over the spillway, which differs greatly from Alternatives 2A, 2B, 3A, and 3B. Cumulative impacts to traditional cultural properties are anticipated to be similar to those described in the NAA and Alternative 1, and less impactful than Alternatives 2A, 2B, 3A, and 3B. Alternative 4 and Alternative 1 would cause the most direct adverse effects to built resources including seven historic districts. Overall, the cumulative effects do not greatly increase adverse effects or create beneficial effects beyond what is discussed in section 3.21.

#### *4.24.2.8 Alternative 5 – Refined Integrated Water Management Flexibility and ESA-Listed Fish Alternative (Includes Operational Downstream Passage at Cougar Drawdown to Diversion Tunnel)*

Compared to NAA, Alternative 5 would likely result in minor to major beneficial water temperature effects in the North Santiam, South Santiam, and South Fork McKenzie sub-basins due to the proposed temperature control structure at Detroit dam, Green Peter deep autumn drawdown with operational temperature control, and a deep drawdown at Cougar. Minor to moderate beneficial TDG effects are expected in the North Santiam and South Fork McKenzie sub-basins due to a reduced number of days with spill (at Detroit, the proposed temperature control structure removed the need for operational temperature control with non-turbine outlets). Minor beneficial TDG effects are expected in the South Fork McKenzie sub-basin under Alternative 5 due to the deep drawdown at Cougar that involves use of the diversion tunnel, which is expected to have lower TDG than the regulating outlet. Moderate adverse TDG effects are expected below Green Peter Dam (above Foster Lake) due to the Green Peter deep autumn drawdown that relies on more spill flow in Alternative 5. Cumulative effects from the RFFAs have the potential to modify water temperature, turbidity, HABs, and mercury in some of the WVS watersheds. In general, the cumulative effects from the RFFAs would result in negligible adverse effects or may increase negative effects to an unknown degree.

For fisheries, Alternative 5 is functionally similar to Alternative 2B and it is anticipated that the cumulative effects under Alternative 5 will be indistinguishable from cumulative effects under Alternative 2B. Alternative 5, similar to alternatives 2A and 2B, is integrated water management alternative with small hydrological differences. Downstream minimum flows are different below Big Cliff, Foster, Cougar, and Dexter dams, otherwise fish passage and water quality measures are the same in alternatives 5 and 2B. Operational fish passage at Cougar Dam proposed for this Alternative is estimated to be more effective that that proposed for Alternative 2A at Cougar Dam.

Overall, cumulative effects to wildlife and wildlife habitat would be major over the period of analysis. Changes to wildlife and wildlife habitat in terms of biodiversity and suitable habitat availability would be affected by climate change, water withdrawals, and habitat fragmentation due to development. Alternative 5 (as with Alternative 2B) would also have moderate effects to wildlife and wildlife habitat within the WVS primarily due to drawdowns in the reservoirs. These effects would be interactive and would be major in most subbasins. Most notably at Cougar reservoir, because deep fall and spring drawdowns would be included as a part of Alternative 5 (as with Alternative 2B) there would be potential for major effects to aquatic and wetland habitat around the reservoir when combined with climate change effects.

For cultural resources, cumulative effects associated with Alternative 5 are anticipated to be the same as Alternative 2B. This alternative, like the other alternatives, follows a rule curve that results in one major cycle of draft and fill per water year, which has major direct irreversible adverse effects to archaeological resources. The cumulative effects of past, present, and reasonably foreseeable actions would be additive, major, and adverse to archaeological sites. For traditional cultural properties, the cumulative effects vary from beneficial to adverse, but most are potentially reversible with the exception of the destruction of archaeological sites that may be part of traditional cultural properties. Built resource cumulative impacts would be the same as those described in Alternative 2B, and moderate to major direct effects would occur at seven of the historic districts. Overall, the cumulative effects do not greatly increase adverse effects or create beneficial effects beyond what is discussed in section 3.21.

# CHAPTER 5 - PREFERRED ALTERNATIVE SELECTION AND IMPLEMENTATION

## 5.1 INTRODUCTION

This chapter focuses on how the Preferred Alternative was selected by USACE for the Draft PEIS. CEQ's NEPA regulations require an agency to disclose the Preferred Alternative in the draft EIS if one has been identified, 40 CFR 1502.14(e). Selection of the Preferred Alternative in no way precludes the agency from selecting a different alternative once it has had the benefit of public review and comment in the Final EIS and ROD. Identification of the Preferred Alternative and discussion of the rationale for selecting that alternative as the preferred does not predetermine the agency's final decision based on completion of the FEIS, rather it provides the public with the opportunity to understand the agency's current reasoning so that they may provide meaningful comments.

Given the complexity of this project and its implementation, this chapter also summarizes a timeline for implementation of the preferred alternative, the framework for adaptive management of a selected alternative, and the governance framework or structure for working with WATER to implement the selected alternative. Implementation plan and Adaptive Management Plan (AMP) in Chapter 5 and Appendix N is discussed solely for the purpose of providing the public with a sense of how USACE would structure these plans as applied to the alternative that is ultimately selected and documented in the ROD.

The Preferred Alternative is provided in the PEIS to provide important context and to comply with NEPA requirements to identify a Preferred Alternative. The AMP and governance structure described in this chapter and in more detail in Appendix N would apply broadly to any alternative selected in the ROD, though specific components of the AMP (like metrics) may need to be refined for a particular measure in an alternative. A unique implementation plan would need to be developed for whatever alternative is ultimately selected because construction timing and sequencing for large structural changes cannot be as easily adjusted or translated across different alterntives.

Chapter 5 is organized as follows:

**5.2 Comparison of Alternatives** – Summarizes the evaluation criteria and process for comparing the alternatives and selecting the Preferred Alternative; also evaluates the differences between the alternatives.

**5.3 Summary of the Preferred Alternative** – Summarizes the Preferred Alternative. Section 5.3.1 in the Final PEIS will also explain components of the Preferred Alternative that were further refined during ESA consultation with NMFS and USFWS and in response to public comments on the Draft PEIS. Section 5.3.1 in the Final PEIS will also describe the effects associated with refined components.

**5.4 Implementation Plan** – Summarizes how USACE would execute the Preferred Alternative under the Implementation Plan.

**5.5 Adaptive Management Plan** – Summarizes the framework for implementing actions for the Preferred Alternative under an adaptive management plan, this is be updated for the selected alternative in the FEIS. This includes assessment of actions taken, assessing hypotheses and outcomes, and introducing new actions, should they become necessary. It also describes the process including the potential for additional NEPA and ESA consultation to implement different actions.

This section also summarizes the Governance Program used to make decisions based on recommendations from the Willamette Action Team for Ecosystem Restoration (WATER) resulting from adaptive management assessments.

## 5.2 COMPARISON OF ALTERNATIVES

The potential effects associated with each of the alternatives have been assessed and the analyses are discussed in detail in Chapter 3 and further described in the associated appendices. This section provides an overview of how the alternatives were evaluated and compared for the selection of the Preferred Alternative.

USACE developed multiple criteria to evaluate how effectively each alternative met the Proposed Action objectives described in Section 2.1 with consideration of cost and the economic, environmental, and social effects and then performed a tradeoff analysis using these criteria to compare the alternatives. To develop criteria, USACE considered the benefits and environmental and social consequences as reflected in Chapters 3 and 4 and then assessed the tradeoffs presented under each alternative within and outside of current authorities.

There was little differentiation among the levels of environmental and social impacts across alternatives. Therefore, the effects to environmental and social resources were not deemed an applicable criterion to evaluate how effectively an alternative met the Proposed Action objectives.

In contrast, the cost to design, construct, and operate and maintain the WVS under each alternative in combination with impacts to recreation, hydropower production, water supply, and ESA-listed fish did provide clear tradeoffs for comparing alternatives. To develop criteria to capture this combination of costs and impacts, one or more metrics were developed to measure how effectively an alternative would meet each of the primary objectives outlined in Section 2.1 except for Objectives 2 and 7.

Objective 2, to increase opportunities for the creation of nature-based structures during maintenance of USACE-owned revetments, and Objective 7, to reduce spawning and rearing habitat competition caused by hatchery fish, would be effectively met by including the revetment and hatchery measures, respectively, under each action alternative. As all action alternatives include revetment and hatchery measures, there is no measurable difference in how well they meet these objectives.

In addition to metrics evaluating how effective an alternative is at meeting the Proposed Action objectives, metrics for cost and the economic effects resulting from impacts to recreation were also assessed. The metrics for the remaining objectives, the economic metrics for impacts to recreation, and the metrics for costs are described below.

### 5.2.1 Objective 1- Effectiveness Criteria Metrics

Two metrics were used to measure how effectively each alternative met Objective 1 to allow greater flexibility in water management:

- conservation storage
- impacts to downstream flows

Conservation storage identifies the total peak volume of water in acre-feet the WVS can store in the conservation season. Basically, the more water the WVS can store in the spring, fall, and summer the more responsive USACE can be to operate the system to support all the competing uses, including flows for water supply, hydropower production, water quality, and fish and wildlife as well as the maintenance of reservoir elevations for recreational use. Conservation storage was assessed for each alternative using ResSim as described in Section 3.2. The difference between the total conservation storage under the NAA and each action alternative is provided in Table 5.2-1.

The impact to flows at downstream control points is a qualitative assessment of the difference in flows at Salem between the NAA and each action alternative. Flows at Salem were assessed under each alternative using ResSim as described in Section 3.2. The difference between flows at Salem under the NAA and each action alternative is provided in Table 5.2-1.

Details on this analysis can be found in Section 3.2.2 and 3.13.2 and Appendices B and J.

### 5.2.2 Objective 3 - Effectiveness Criteria Metric

Net Present Value (NPV) is the metric USACE used to measure how effectively each alternative meets Objective 3 to allow greater flexibility in hydropower production when compared to the no action alternative. An alternative's NPV assesses the long-term economic viability of the hydropower plants, given implementation of the alternative.

As discussed in Section 3.12, NPV measures the impact to the economic viability of hydropower at WVS hydropower dams by comparing the expected revenue produced at the hydropower facility across the WVS to the expected future costs at the facilities, including the cost to implement the alternative. This metric helps assess the changes in hydropower generation, including any potential resulting effects on the regional energy environment, and the impact the cost to implement each alternative has on hydropower revenues.

Details on this analysis can be found in Section 3.12.2 and Appendix G.

### 5.2.3 Objectives 4 through 6 Effectiveness Criteria Metrics

Objectives 4 through 6 all pertain to meeting the needs of ESA-listed fish species and include:

- Objective 4. Increase anadromous ESA-listed fish passage survival.
- Objective 5. Improve water management during the conservation season to benefit anadromous ESA-listed species.
- Objective 6. Reduce pollutant levels to restore impaired water quality to benefit anadromous ESA-listed species.

As described in Section 3.8.2, this draft PEIS evaluates effects on ESA-listed fish species and aquatic habitat using a quantitative (ESA-listed salmon and steelhead and critical habitat) and qualitative (bull trout and habitat) framework. The quantitative framework relies on output from a suite of models developed for ESA-listed salmon and steelhead including the Ecological Diagnosis Treatment (EDT) model, the Integrated Passage Asses (IPA) model, and the National Oceanic and Atmospheric Administration Life Cycle Model (LCM).

The fish models account for effects at a population scale of the measures under the alternatives cumulatively with the other major factors occurring in the watershed as described in Chapter 4. As all major factors outside the alternative measures are the same across alternatives, the model outputs inform the level of effects each alternative would have on the species at a population level.

These models incorporate inputs for passage survival (Objective 4), appropriate flows for habitat conditions supportive of the different life stages within the river system during the conservation season (Objective 5), and improved water quality (Objective 6). Therefore, metrics derived from the outputs of these population models demonstrate the effectiveness of an alternative for all three ESA-specific objectives identified in Section 2.1.

For example, to illustrate how the models measure improved water quality per Objective 6, provides an influence diagram that shows how the water quality parameters important for ESA species survival (Total Dissolved Gas [TDG] and temperature) are intrinsic to the life cycle models used to evaluate the alternatives' effects on the listed salmonid species. This demonstrates how the quantitative framework integrates water quality parameters and, therefore, addresses Objective 6 specifically.

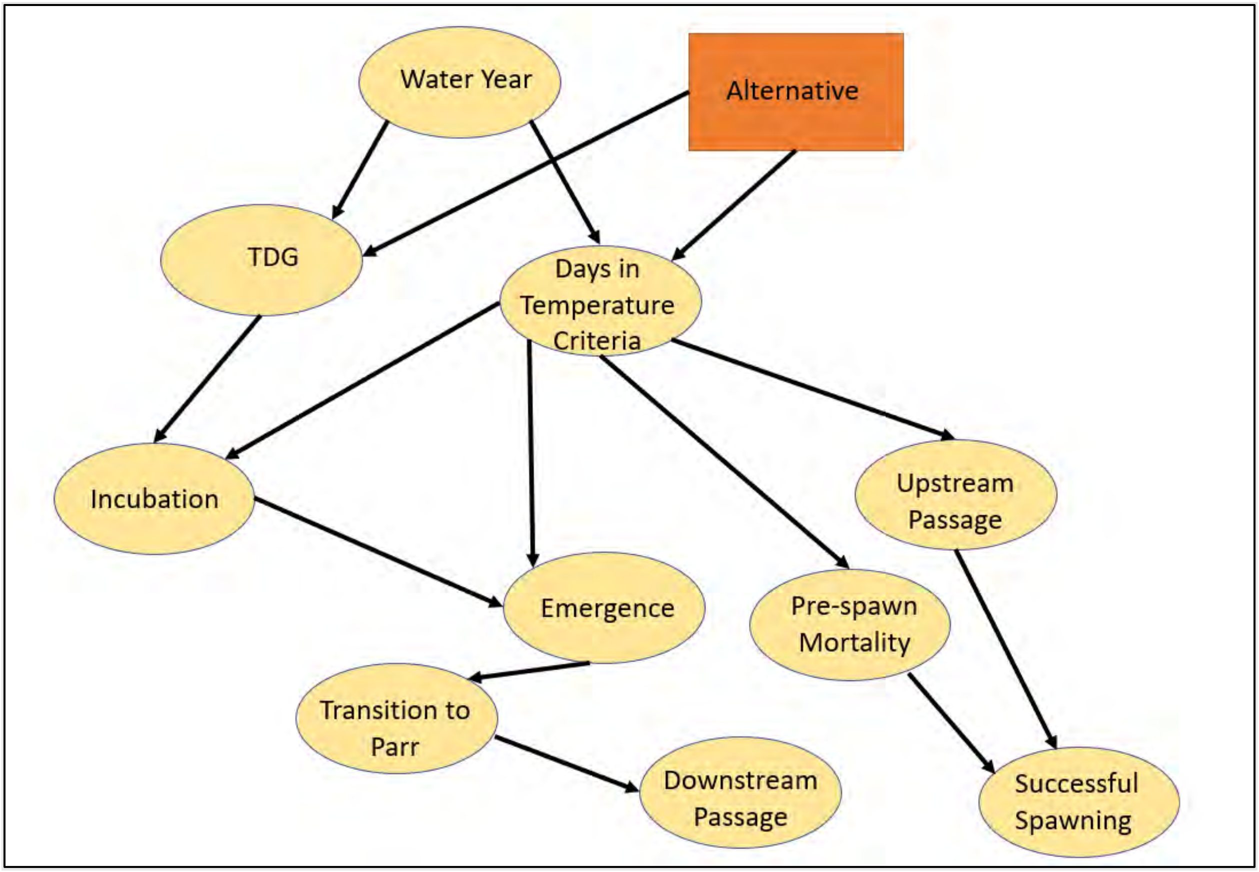


**Figure 5.2-1. Water quality influence diagram for WVS ESA listed Salmonids**

Five metrics were developed based on the outputs from these models to assess how effectively each alternative meets Objectives 4, 5, and 6. At the time the alternatives comparison and selection process occurred, only the UWR spring Chinook salmon modeling results were available; therefore, metrics specific to UWR steelhead are not included. However, USACE did review the UWR steelhead results; the UWR steelhead information does not change the rankings of the alternatives.

The five metrics used for evaluating and comparing how effectively the alternatives meet Objectives 4, 5, and 6 include:

- **Number of populations where maximum recruits/spawner (R/S) is greater than (>) 1:** The number of UWR spring Chinook salmon populations (a total of four are affected by the WVS) modeled to achieve spawner replacement on average over a 30-year timeframe. A high number is preferred. Spawner replacement occurs when offspring return to spawn in numbers equal to or greater than the number of parental spawners they were produced from. When the population replacement rate is less than 1, on average the population declines.
- **Number of populations with high persistence:** The number of UWR spring Chinook salmon populations modeled to exceed a minimum adult abundance threshold. A higher number is

preferred. The minimum adult abundance thresholds for each UWR spring Chinook salmon population were identified by the Technical Recovery Team.

- **Legacy population risk of extinction:** Indicates McKenzie Core Legacy spring Chinook salmon population risk of extinction.
- **Downstream survival relative rank**: Relative rankings of model results of UWR spring Chinook salmon and UWR steelhead survival below dams as affected by flow and water temperatures. A higher number is preferred. See appendix A for details on the ranking process.
- **Number of bull trout populations with habitat gains:** Number of bull trout populations with habitat gains from fish passage improvements allowing access downstream of WVS dams. A higher number is preferred. This assessment assumes bull trout are reintroduced above Detroit Dam. Bull trout currently reside above Cougar and Hills Creek Dams among WVS dams.

  Risk level refers to the assessment score for bull trout under each alternative, primarily relating to accessing habitat below dams. Biological risk is generally assumed to increase with downstream passage improvements.

Details on this analysis can be found in Section 3.8.2 and Appendix E. There are no metrics for UWR steelhead populations because this model output was not available at the time of the alternatives evaluation and comparison phase for identifying the Preferred Alternative. However, when UWR steelhead results became available, USACE determined the results would not change the decision.

### 5.2.4 Cost Criteria and Metrics

The cost of an alternatives was evaluated using the annual costs over the 50-year period of analysis in 2021 dollars. The annual cost includes annualized first costs for design and construction as well as the annual cost for Operations, Maintenance, Repair, Replacement and Rehabilitation as described in Section 1.8.7. Costs were estimated based on existing studies for similar projects. Costs were then scaled to site-specific needs. Cost estimate details for each alternative can be found in Appendix M.

### 5.2.5 Economic Metrics for Effects to Recreation

During public scoping, effects to recreation and the associated economic effects were identified as important to stakeholders as described in Appendix Q. For this reason, these effects were considered in evaluating and comparing the alternatives. The following economic metrics were used to assess effects to recreation:

**Average annual recreation benefits (total for all reservoirs):** This metric measures changes in availability of reservoir boat ramps and the changes in visitation across various recreation activities that are estimated to occur when boat ramps are available versus when they are not available across the Willamette Valley Basin (WVB) from the NAA. The measure of changes is in the dollar value of reservoir recreational visitations during the recreation season (April 15 through Sept 15). The dollar value of visitations is derived from Unit Day Value data provided by the Institute for Water Resources (USACE 2021). The higher the value, the greater the economic benefits as compared to the NAA.

**Regional economic impact from recreation effects:** This is a qualitative assessment considering the full-time jobs created/lost by the changes in water levels resulting from the measures under each alternative, making conditions more/less conducive to water-based recreation and the regional (sub-basin) output. The regional output is equal to the sum of employee compensation, plus proprietor income, plus other property type income, and plus indirect business taxes.

This analysis was predicated on the potential effects to localized jobs associated with dollars gained or lost as a function of water level fluctuation at a particular project's county. The higher the impact the greater the projected number for jobs lost and reduction in regional output. An assessment of a low impact means there would be negligible impact to the numbers of jobs lost and little to no reduction in regional output. The analysis does not reflect the transfer of recreation utility from one site to another within the collective basin.

An assessment of a medium impact means there would be greater than one job lost in any basin and a reduction in regional output less than $150,000 in multiple basins. An assessment of a high impact means greater numbers projected for jobs lost and a corresponding reduction in regional output greater than $150,000 in multiple counties or basins.

Details on this analysis can be found in Section 3.14.2 and Appendices K and I.

### 5.2.6 Summary of Alternatives Comparison

Although absolute values provide important context, it is more relevant for decision-makers to consider the estimated differences between each of the action alternatives and the NAA. Table 5.2-1 shows the differences in the performance that would occur under Alternatives 1 through 5 in relation to the NAA.

The methodology and analysis for each metric is provided in the associated analyses of environmental consequences in Chapter 3, and the associated appendices. Table 5.2-1 summarizes and compares the results of the evaluation criteria for each alternative as compared to the NAA.

**Table 5.2-1. Alternatives Criteria Comparison to NAA[1]**

| Criteria | Metric | No Action Alternative | Alt 1 | Alt 2A | Alt 2B | Alt 3A | Alt 3B | Alt 4 | Alt 5 |
|---|---|---|---|---|---|---|---|---|---|
| Effectiveness meeting Objective 1 | Change in Conservation Storage from NAA (acre-feet) | 1,329,000 | +168,000 | +122,000 | -64,000 | -590,000 | -669,000 | +122,000 | -98,536 |
| Effectiveness meeting Objective 1 | Impact to flows compared to NAA | – | Low | Low | Medium | High | High | Low | Medium |
| Effectiveness meeting Objective 3 | Change in NPV from NAA ($ millions) | $225 | -$1,159 | -$863 | -$933 | -$853 | -$829 | -$1,162 | -$939 |
| Effectiveness meeting Objectives 4-6 | UWR spring Chinook salmon populations reaching replacement | 2 of 4 UWR spring Chinook salmon populations reach replacement | +1 population | +2 populations | +2 populations | +2 populations | +2 populations | +1 population | +2 populations |
| Effectiveness meeting Objectives 4-6 | UWR spring Chinook salmon population persistence | 1 of 4 UWR spring Chinook salmon populations with high persistence | +1 population | +2 population | +1 population | +0 populations | +1 population | +1 population | +1 population |
| Effectiveness meeting Objectives 4-6 | McKenzie Core Legacy spring Chinook | McKenzie Core Legacy spring Chinook | No change in risk | Risk reduced | Risk reduced | No change in risk | No change in risk | Risk reduced | Risk reduced |

| Criteria | Metric | No Action Alternative | Alt 1 | Alt 2A | Alt 2B | Alt 3A | Alt 3B | Alt 4 | Alt 5 |
|---|---|---|---|---|---|---|---|---|---|
| | salmon population risk | salmon population is at risk | | | | | | | |
| Effectiveness meeting Objectives 4-6 | Downstream survival relative rank: 1=best, 7=worst | 7 | 1 | 2 | 4 | 5 | 6 | 3 | 4 |
| Effectiveness meeting Objectives 4-6 | Bull trout habitat gains | No habitat gains for bull trout | Least habitat gains for bull trout | Habitat gains for bull trout | Habitat gains for bull trout | Habitat gains for bull trout | No habitat gains for bull trout | Habitat gains for bull trout | Habitat gains for bull trout |
| Estimated Total Annual Cost | Millions of US $ | $9 | +$95 | +$58 | +$53 | +$17 | +$21 | +$104 | +$53 |
| Economic impact to recreation | Change in Average Annual NED Recreation Benefits (total for all reservoirs in millions of dollars) from NAA | $20.45 | +$0.31 | +$0.17 | +$0.02 | -$0.76 | -$1.27 | +$0.17 | +$0.02 |
| **Acceptability Criteria:** Economic | Impact to RED from Recreation Effects | – | Low | Medium | Medium | High | High | Medium | Medium |

[1]No color indicates no, negligible, or minor effects
Green indicates a positive/beneficial effect
Yellow indicates a moderate negative/adverse effect
Orange indicates a high negative/adverse effect

### 5.2.7 Discussion of Consequences

This section summarizes the differences between alternatives, including relative costs and hydrologic differences as well as some of the implications of these differences for hydropower, water supply, recreation, and endangered species in terms of relative benefits and adverse effects compared with the NAA. As all alternatives have similar outcomes for the environmental and social effects metrics, these effects will not be discussed further. This section also provides a brief summary of the USACE evaluation, including key risks and uncertainty, that influenced the decision-making process in identifying the Preferred Alternative.

#### *5.2.7.1 No Action Alternative*

The NAA is a continuation of the operation of the WVS and management actions being used to comply with the 2008 BiOp (NMFS 2008) as operated at the start of this effort in the spring of 2019. Per CEQ 40 Most Asked Questions regarding NEPA, no action means no change from current management direction or level of management intensity. This PEIS defines no action similarly - no change in direction from existing O&M of the WVS as of 2019. The NAA is designed to continue the management practices and operation of the WVS, with the addition of increased releases for municipal and industrial (M&I) water storage agreements. The NAA serves as a benchmark to compare effects across action alternatives.

##### *5.2.2.1.1 Tradeoffs*

The NAA is predicted to have major adverse effects on UWR spring Chinook salmon and UWR winter steelhead. High extinction risk in all sub-basins is predicted for both species. The NAA would be insufficient in meeting the Proposed Action ESA Objectives (objectives 4-6). Of the four Chinook salmon populations, two populations would decline and only one population would have high persistence (e.g., have low extinction risk). Additionally, under the NAA the McKenzie Core Legacy spring Chinook salmon population would be at risk and, there would be major adverse effects to the UWR winter steelhead resulting in a high risk of extinction.

The NAA would not result in habitat gains for bull trout, and it is the lowest ranked (7) of all alternatives for downstream survival. Adverse effects on bull trout are predicted to be minor. Bull trout above Cougar have been stable for several years and have been increasing above Hills Creek. Habitat scores for bull trout are reasonable, with 100 percent of the available spawning habitat available, and 70 percent of the rearing habitat available. Passage conditions at dams limit bull trout access to below dam rearing habitat.

Climate change is predicted to further degrade habitat below dams and will reduce the ability to meet operational fish passage, minimum flows, and water temperature objectives below dams. See Appendix F for details on climate change effects on the WVB.

The NAA is the only alternative to utilize the BiOp flows targets established in 2008 as described in Section 2.4.1.1. Under the NAA the 75 percent exceedance level of system-wide stored water is estimated to be 1,331,864 acre-feet, and there would be no to negligible effect on hydrologic processes or flows downstream. However, this means that, under the NAA, there would not be flexibility in water management related to refill, drawdown timing, and other water management measures. For example, under the NAA operations that use the power pool or inactive pool (Sections 2.2.1.3 and 2.2.1.4 respectively) when needed to augment flows for biological purposes would not be available. Instead under the NAA only the conservation pool may be used to meet flow targets late in the fall, reducing operational flexibility for meeting flow targets. Since the WVS would be operated as designed and there would be no new structural modifications that would increase complexity, there would be a low mechanical and operational risk associated with the NAA.

Under the NAA, power generation for combined WVS projects would continue to be marginally economically viable. The median NPV for the combined WVS is about $225 million. Conservation storage would result in enough stored water to meet the M&I and agricultural irrigation (AI) demands in almost all years. Water would be released from the reservoirs to satisfy projected demands of stored water for M&I uses at the 2050 demand level and existing, as of April 2019, AI water service contracts. Additionally, the recreational experience would not change compared to current conditions, meaning there would be no effects to average annual visits or average annual benefits, and no changes to full-time jobs or the regional output.

The estimated total annual cost estimate for the NAA is $9,279 million (see Appendix M for details). The NAA provides a baseline for understanding the costs associated with operating and maintaining the WVS. The NAA also provides a starting point for determining how costs will change as various structural or operational changes or both are made under action alternatives. Under the NAA, agencies will continue to maintain system infrastructure, while routine O&M costs would occur for hydropower, cultural resources, recreation, fish and wildlife, and other routine costs. The NAA includes some proposed funding increases in routine O&M activities at Detroit/Big Cliff, Foster, Cougar, Lookout Point/Dexter, and Fall Creek reservoirs.

Overall, the NAA would perform the best for hydropower and recreational interests with marginal benefits to storage compared to some the action alternatives. Although there would be a low mechanical and operational risk under the NAA, power generation would only be marginally viable. This alternative would also have the greatest adverse effects on listed fish species. Given that USACE must comply with the ESA to continue to operate and maintain the WVS, and an appropriate level of action is necessary, the NAA is not a selectable alternative. The primary purpose of the NAA is to serve as a benchmark against which to compare the relative benefits and adverse effects of the action alternatives.

#### *5.2.7.2 Alternative 1. Improve Fish Passage Through Storage-focused Measures*

The purpose of Alternative 1, also referred to as the Project Storage Alternative, is to maximize the refill volumes of conservation pools at WVS reservoirs to meet authorized purposes that depend on full reservoirs, including M&I and AI water supply, recreation, and water quality as well as to improve fish passage through the WVS dams to increase the survival of ESA-listed fish species. Alternative 1 is designed to increase the probability of refilling the WVS reservoirs and use a greater portion of the total reservoir volume for conservation storage, including the inactive and power pools than under the NAA. One goal of alternative 1 is to fill the reservoirs as often as possible and to supply water from storage as late into the conservation season as possible through changes in operations.

The main operational features under Alternative 1 are to reduce minimum flows to congressionally authorized minimum flow requirements from the NAA 2008 BiOp flows, as well as, to augment instream flows by using the power and inactive pools which is not done under the NAA. Alternative 1 also proposes only structural measures for fish passage and water quality as shown in Table 5.2-2.

**Table 5.2-2. Water Quality and Passage Measures Under Alternative 1**

| Dam | Temperature Control | TDG Improvements | Downstream Fish Passage | Upstream Fish Passage |
|---|---|---|---|---|
| Dexter | – | Structural* | – | – |
| Lookout Point | Structural* | – | Structural* | – |
| Hills Creek | – | – | – | – |
| Fall Creek | – | – | – | Structural* |
| Cougar | – | Structural* | – | – |
| Blue River | – | – | – | – |
| Foster | Structural | Structural* | Structural | – |
| Green Peter | Structural* | Structural* | Structural* | Structural* |
| Big Cliff | – | – | – | – |
| Detroit | Structural | – | Structural | – |

*Distinctive feature of this alternative.

Alternative 1 is like Alternative 4, which focuses on structural measures to accomplish downstream passage and water quality management. For instance, Alternatives 1 and 4 are also the only alternatives to propose restoring upstream and downstream passage at drop structures and structures to abate TDG which adds to their total costs. However, there would be several differences in the total number and the locations of these structures.

The difference between Alternative 1 and Alternative 4 with respect to structures is that they propose temperature control and downstream passage structures at different dams, and Alternative 4 proposes an additional downstream passage structure compared to Alternative 1. These differences allow for the comparison of the relative costs and benefits associated with the different combinations of structural measures across the action alternatives. There are no structures proposed under the NAA.

Table 5.2-3 shows this comparison of structural measures between Alternative 1 and 4.

**Table 5.2-3. Alternatives 1 and 4 structural measure comparison**

| Dam | Alternative 1 water temperature structure | Alternative 4 water temperature structure | Alternative 1 structural downstream passage | Alternative 4 structural downstream passage |
|---|---|---|---|---|
| Detroit | X | X | X | X |
| Foster | X | X | X | X |
| Green Peter | X | – | X | – |
| Cougar | – | – | – | X |
| Hills Creek | – | X | – | X |
| Lookout Point | X | X | – | X |

*5.2.2.2.1 Tradeoffs*

Under Alternative 1, large floating fish passage structures would be implemented in the North, South Santiam, and the Middle Fork Rivers. These structures do not require an increased release of conservation storage to facilitate passage or their use when compared to the NAA. A fall[62] deep drawdown at Fall Creek would also continue from the NAA. Flow targets from HD 531 support capturing increased amounts of water in reservoirs during spring as compared to all other alternatives including the NAA.

Despite the spending on structural measures, Alternative 1 would only marginally meet the Proposed Action ESA objectives (objectives 4-6). Although Alternative 1 did rank the highest out of all alternatives for downstream survival and three out of four Chinook salmon populations would reach replacement, only two out of four Chinook salmon populations would have high persistence (e.g., low risk of extinction). Additionally, the McKenzie Core Legacy spring Chinook salmon population would be at risk of extinction. Under Alternative 1, there would also be the least habitat gains for bull trout compared to the NAA due to lack of effective downstream passage at Cougar Dam. Alternative 1 implementation is predicted to have major effects on Chinook salmon and minor adverse effects on winter steelhead populations in the North and South Santiam sub-basins. Scores and risks for bull trout would be like the NAA, with minor effects predicted. Habitat scoring for bull trout would be only marginally better than under the NAA with rearing habitat increases for North Santiam bull trout below Detroit.

Unlike the NAA, structural improvements for fish passage and water temperature would provide resilience to adverse climate change impacts by increasing operational flexibility in the North Santiam, South Santiam, McKenzie, and Middle Fork sub-basins. See Appendix F for details on climate change effects on the WVB.

Compared to the NAA, Alternative 1 would result in minor to major beneficial water temperature effects in the Middle Fork Willamette, South Santiam, and North Santiam sub-basins due to the proposed temperature control structures at Lookout Point, Green Peter,

[62] The terms “fall” and “autumn” are synonymous in this chapter in reference to seasonal drawdown periods.

Detroit Dams. Minor to major beneficial TDG effects are expected in the North Santiam and South Fork McKenzie sub-basins based on the reduced number of spill days and proposed TDG abatement structures under Alternative 1.

Because of many of the structural measures, reservoirs would not be drawn down for temperature management and downstream fish passage operations under Alternative 1. This, coupled with the proposed operation to reduce minimum flows to congressionally authorized minimum flow requirements, would result in the greatest increase in total water stored by mid-May of all alternatives, at an estimated increase in peak water stored system-wide under the NAA by 168,000 acre-feet in the driest year. This would result in a moderate beneficial effect to M&I water supply and AI users of the conservation storage space under Alternative 1.

The increase in total water stored and flow measures under Alternative 1 would result in the same or higher downstream flows in the summer as compared to the NAA. Flows in the mainstem Willamette River at Salem would be lower than under the NAA from mid-May through June, but flows would remain high and above 6,000 cfs. As modeled, flows at Salem during the summer would be higher than under the NAA, rarely dropping below 6,000 cfs. This would result in a minor beneficial effect to existing M&I water supply and AI users from increased summer flows in the driest years. However, as discussed in Section 3.13, in the driest years, the actual impact to M&I and irrigation is currently unquantifiable because the 2019 Willamette Basin Review (WBR) BiOp sets forth a theoretical plan to reduce contracted water availability to protect ESA-listed species that has not yet been formalized.

The additional stored water under Alternative 1 as compared to the NAA would contribute to an overall increase in average annual hydropower generation of 8 aMW (roughly enough to power 6,371 households annually; see Section 3.12.3.2 for details). However, the high capital and O&M cost of Alternative 1 would result in the greatest decrease in NPV from that provided under the NAA.

Under Alternative 1, there would be a $1.159 billion reduction in median NPV to -$934 million. Therefore, there would be long-term, major, adverse effects on economic viability of WVS power generation. There would, however, be negligible risk to local hydropower generation as Hills Creek and Cougar Dams would continue to be able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages due primarily to weather events or fires like the NAA.

Under Alternative 1, the increased stored water and reduction in minimum flows as compared to the NAA would mean that reservoir levels stay higher for more of the conservation season resulting in minor to moderate benefits to reservoir recreation. This would translate into slight increases in annual visitations, resulting in an approximate increase of $300,000 in annual economic benefits (a 1.5% increase) compared to the NAA.

The regional economic impact from recreation effects would be low under Alternative 1. The regional economic effects would be associated with the negligible effects to employment and regional output.

Alternative 1 would be the second costliest alternative to implement (surpassed only by Alternative 4) primarily driven by the cost to design, construct, operate, and maintain structural measures for temperature control, fish passage, and TDG abatement. The estimated total annual cost for Alternative 1 is $104,396 million, $95 million greater than the NAA (see Appendix M for details).

Alternative 1 would increase the probability of refilling the WVS reservoirs and the amount of water available for conservation purposes later in the season. This alternative would result in the greatest increase in total water stored by mid-May of all alternatives. Further, there would be an overall increase in average annual hydropower generation and minor to moderate benefits to reservoir recreation under Alternative 1.

However, due to the scale of actions required under Alternative 1, this is the second most expensive alternative. The high cost makes it unlikely this alternative would be acceptable to many stakeholders, agencies, and the public. Although there would be some benefits to fish species such as resilience to adverse climate change impacts from structural modifications, this Alternative 1 would result in fewer benefits to ESA species overall than several less costly alternatives, including Alternatives 2A, 2B, and 5. Therefore, Alternative 1 was not identified as the preferred alternative.

#### *5.2.7.3 Alternative 2A. Integrated Water Management Flexibility and ESA-listed Fish Alternative (Includes Structural Downstream Passage at Cougar Dam)*

Alternative 2A, also referred to as the Hybrid Alternative with Cougar Floating Screen Structure (FSS), was developed to improve fish passage through the WVS dams, as compared to the NAA, utilizing a combination of modified operations and structural improvements, along with other measures to balance water management flexibility and to meet requirements for ESA-listed fish. Under Alternative 2A, the “Integrated Temperature and Habitat Flow Regime” operation replaces the 2008 BiOp flows under the NAA. This would shift the release of stored water from the spring to the summer and fall, most notably in dry years. Flows would be reduced within a range down to minimums needed for fish survival when reservoirs are under 90% of rule curve elevation as compared to NAA. While these minimums would be less than the BiOp targets, they would be adaptive within a water year and could return to levels that are higher than the BiOp flows under the NAA if reservoir levels are high. Alternatives 2B, 3A, 3B, and 4 also include this flow measure.

The other main operational features of Alternative 2A that differ from the operations in the NAA is the augmentation of instream flows by using the power and inactive pools and a spring spill and deep draw down for fish passage at Green Peter. Alternative 2A also proposes a combination of structural measures for fish passage and temperature control which are not in the NAA, as shown in Table 5.2-4. As under Alternative 1, and in contrast to the NAA, structural improvements for fish passage and water temperature would provide resilience to adverse climate change impacts on fish species by increasing operational flexibility.

As under the NAA, Alternative 2A does not include the structural improvements for TDG abatement included in Alternatives 1 and 4 or the fish passage and temperature structures at Hills Creek Dam under Alternative 4. In contrast to Alternative 1 but like all other action alternatives, Alternative 2A proposes operational measures utilizing the spillway and regulating outlets (ROs) for temperature management at Green Peter Dam. Alternative 2A also includes a deep fall drawdown and spring spillway operations for fish passage at Green Peter Dam, unlike Alternatives 1, 4, and the NAA .

The only difference between Alternative 2A and 2B is in their downstream passage measure at Cougar Dam. Alternative 2A proposes structural downstream fish passage at Cougar Dam whereas Alternative 2B proposes operational fish passage at Cougar Dam. The NAA does not provide operational or structural fish passage at Cougar Dam. Alternative 5 also proposes operational fish passage instead of structural fish passage as well as proposing a refined flow operation that slightly differs from the “Integrated Temperature and Habitat Flow Regime” operation under Alternatives 2A through 4 and the 2008 BiOp flow targets in the NAA.

**Table 5.2-4. Water Quality and Passage Measures Under Alternative 2A.**

| Dam | Temperature Control | TDG structural Improvements | Downstream Fish Passage | Upstream Fish Passage |
|---|---|---|---|---|
| Dexter | – | – | – | – |
| Lookout Point | – | – | Structural | – |
| Hills Creek | – | – | – | – |
| Fall Creek | – | – | – | – |
| Cougar | – | – | Structural * | – |
| Blue River | – | – | – | – |
| Foster | Structural | – | Structural | – |
| Green Peter | Operational* | – | Operational* | Structural* |
| Big Cliff | – | – | – | – |
| Detroit | Structural | – | Structural | – |

*Distinctive feature of this alternative.

### *5.2.2.3.1 Tradeoffs*

Alternative 2A has an integrated management strategy theme. This alternative includes structural downstream passage at Detroit, Foster, Cougar and Lookout Point Dams, and operational passage at Green Peter Dam. A fall deep reservoir drawdown at Fall Creek Dam that is in the NAA would continue.

Alternative 2A would most effectively meet the Proposed Action ESA objectives (objectives 4-6) for most dams compared with all other alternatives. Alternative 2A ranks second for downstream survival, with all four Chinook salmon populations reaching replacement, and three out of four Chinook salmon populations with high persistence (e.g., low risk of extinction). Alternative 2A would also reduce risk to the McKenzie Core Legacy spring Chinook salmon population and provides more habitat gains for bull trout compared to the NAA due to the inclusion of effective downstream passage at Cougar. In addition, fish passage at Detroit Dam as part of Alternative 2A would provide access to more habitat for bull trout once they are introduced above that dam as compared the NAA. Alternative 2A would have moderate adverse effects on Chinook salmon, predicted to produce the most viable populations compared to the NAA and the other alternatives and would retain the McKenzie Core Legacy spring Chinook salmon population.

Alternative 2A would also produce the most optimistic outcomes for Chinook salmon in the Middle Fork sub-basin among the alternatives, including the NAA, accomplished with a downstream passage structure at Lookout Point exclusive of passage at Hills Creek. Alternative 2A would have minor adverse effects to Santiam winter steelhead populations. Alternative 2A would have minor adverse effects for bull trout. Bull trout habitat scores and risks are comparable to Alternative 1, with a fish passage addition providing access to habitat below Cougar Dam. Habitat scores are higher as compared to the NAA.

Alternative 2A is almost identical to Alternatives 2B and 5. The primary difference in measures between Alternative 2A and Alternatives 2B and 5 is the downstream fish passage measure proposed at Cougar Dam. Alternative 2A proposes an FSS, and Alternatives 2B and 5 propose a deep drawdown to pass fish through the Diversion Tunnel (DT). In contrast to Alternative 2A, Alternatives 2B and 5 would result in high persistence for only three of the four Chinook salmon populations though all three perform better than the NAA. The difference in the anticipated number of populations with high persistence is because the ESA models assume more optimistic downstream fish passage performance with a structure at Cougar Dam. It is assumed that more extreme operations, like a deep drawdown, may have adverse effects on viable populations downstream.

Structural improvements for fish passage and water temperature would provide resilience to climate change by increasing operational flexibility in the North Santiam, South Santiam, Middle Fork sub-basins, as compared to the NAA. See Appendix F for details on climate change effects on the WVB.

Compared to NAA, Alternative 2A would result in minor to major beneficial water temperature effects in the North and South Santiam sub-basins due to the proposed temperature control structure at Detroit Dam and the Green Peter Dam fall deep drawdown. A temperature control structure at these two locations would not occur under the NAA. Minor to moderate beneficial TDG effects are expected in the North Santiam sub-basin when compared to the NAA due to the proposed temperature control structure at Detroit that removes the need for operational temperature control with non-turbine outlets. Moderate to major adverse TDG effects are expected in the South Santiam sub-basin due to the Green Peter fall deep drawdown that relies on more spill flow under Alternative 2A than under the NAA.

As modeled, Alternative 2A would result in an estimated increase in the 75% exceedance level of total water stored system-wide by mid-May of 122,000 acre-feet from the NAA. The Integrated Flow Regime has lower spring mainstem requirements compared to the 2008 BiOp flows under the NAA. Additionally, because of many of the structural measures proposed under Alternative 2A, no reservoirs except Green Peter would be drawn down for temperature management and downstream fish passage during the conservation season. The combination of lower spring flow targets and minimal drawdowns during the conservation season would result in an increase from the NAA in water stored in the driest years.

Alternatives 2A and 4 are similar in this respect, tying for the second largest increase in mid-May stored water volumes when compared to the other alternatives. The increased stored water would result in a moderate beneficial effect to M&I water supply and AI users of the conservation storage space. However, as discussed in Section 3.13, in the driest years the actual impact to M&I and irrigation is currently unquantifiable because the 2019 WBR BiOp sets forth a theoretical plan to reduce contracted water availability in dry years to protect ESA-listed species that has not yet been formalized.

The anticipated increase in total system-wide stored water and flow measures would result in the same or higher downstream flows in the summer as compared to the NAA. The Integrated Flow Regime would require additional flow based on the air temperature, compared to the 2008 BiOp flows proposed under the NAA. Therefore, flows later in the summer and fall would be higher than the NAA due to the additional accumulated stored water.

Under Alternative 2A, flow in the mainstem at Salem would be lower than under the NAA from April through June about 25% of the time, but flows would remain high, usually above 10,000 cfs. During the summer, flows at Salem would be higher than under the NAA, rarely dropping below 6,000 cfs.

In most years, Alternative 2A would have a negligible effect to existing water rights for M&I water supply and AI in the spring and would have a minor beneficial effect in the summer by increasing summer flows in the driest years as modeled when compared to the NAA. However, as discussed in Section 3.13, in the driest years the actual impact to M&I and irrigation is currently unquantifiable.

The additional storage under Alternative 2A as compared to the NAA would contribute to an overall increase in average annual hydropower generation by 4 aMW (roughly enough to power 3,185 households annually) (see Section 3.12.3.3 for details). However, the high capital and O&M cost of Alternative 2A results in a reduction in NPV from that provided under the NAA.

Under Alternative 2A, there would be a $863 million reduction in median NPV to -$638 million. Therefore, there would be long-term, major, adverse effects on economic viability of WVS power generation as compared to effects under the NAA. However, there would be negligible risk to local hydropower generation as Hills Creek and Cougar dams would continue to be able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages due primarily to weather events or fires.

Under Alternative 2A, the additional water stored system-wide as compared to the NAA would also mean reservoir levels stay higher for more of the conservation season resulting in minor to moderate benefits to reservoir recreation except for at Green Peter Reservoir. Despite the fall drawn down at Green Peter Reservoir, Alternative 2A would translate into slight increases in annual visitations across the WRB, resulting in an approximate increase of $169,000 in annual economic benefits (a 0.83% increase) compared to the NAA.

The regional economic impact from recreation effects would be medium. The regional economic effects would be associated with the potential loss of 1.7 jobs in the South Santiam sub-basin due to the drawdown at Green Peter and a moderate reduction in regional output.

Alternative 2A would be the third costliest alternative to implement (surpassed by Alternative 1 and 4) due to the incorporation of numerous structural measures. The estimated total annual cost for Alternative 2A is $67,561 million, $58 million greater than the NAA (see Appendix M for details).

During the tradeoffs analysis it was difficult to discriminate the differences in effects to ESA species among the alternatives. However, Alternative 2A would have a higher risk of not meeting the Proposed Action ESA objectives at Cougar compared to Alternatives 2B and 5. This is due to a higher uncertainty recognized for the performance of the proposed FSS at Cougar Dam when compared downstream fish passage rates of a deep reservoir drawdown using the DT. However, if the structure is as successful as assumed in the modeling it would out preform the DT fish passage rates.

The topography of Cougar Reservoir presents some unique challenges for designing an FSS. Deep reservoir drawdowns have proven very effective at Fall Creek Dam for downstream passage of juvenile Chinook salmon (NMFS 2014) and would not be impacted by the layout of Cougar Reservoir. In comparison, the range of performance among the few examples of floating fish collectors in operation varies widely, and there is only one example of an FSS operating with similar attributes to WVS dams (large temperature stratified forebay with significant reservoir fluctuation) where juvenile Chinook salmon are present (SWIFT Dam and Reservoir on the Lewis River, Washington). This floating collector has a poor rate of juvenile Chinook salmon collection (Kock et al. 2019).

Finally, if collection rates proved to be low with an FSS at Cougar there are minimal post-operation mitigation options with current technology for improving collection into the FSS. The uncertainty that an FSS would effectively collect fish at Cougar Dam coupled with the cost to design, construct, and operate the facility eliminated Alternative 2A from consideration for the Preferred Alternative.

#### *5.2.7.4 Alternative 2B. Integrated Water Management Flexibility and ESA-listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternative 2B, also referred to as the Hybrid Alternative with Cougar Diversion Tunnel Modification, was developed to improve fish passage through the WVS dams as compared to the NAA utilizing a combination of modified operations and structural improvements, along with other measures to balance water management flexibility and meet ESA-listed fish obligations. Alternative 2B is almost exactly like Alternative 2A and 5. The difference between Alternatives 2A and 2B is the fish passage measure at Cougar Dam.

Alternative 2A would incorporate a structure that operates with existing reservoir fluctuations to pass fish downstream, whereas Alternative 2B includes an operation where the reservoir is drawn down to elevation 1330' to use the DT to pass fish. Alternative 5 also includes this measure but proposes a refined flow operation that slightly differs from the "Integrated Temperature and Habitat Flow Regime" operation under Alternatives 2A through 4.

**Table 5.2-5** shows the major operational and structural features under Alternative 2B.

**Table 5.2-5. Water Quality and Passage Measures under Alternative 2B.**

| Dam | Temperature Control | TDG structural Improvements | Downstream Fish Passage | Upstream Fish Passage |
|---|---|---|---|---|
| Dexter | – | – | – | – |
| Lookout Point | – | – | Structural | – |
| Hills Creek | – | – | – | – |
| Fall Creek | – | – | – | – |
| Cougar | – | – | Operational * | – |
| Blue River | – | – | – | – |
| Foster | Structural | – | Structural | – |
| Green Peter | Operational* | – | Operational* | Structural* |
| Big Cliff | – | – | – | – |
| Detroit | Structural | – | Structural | – |

*Distinctive feature of this alternative.

##### *5.2.2.4.1 Tradeoffs*

Alternative 2B also has an integrated management strategy theme. The only difference with Alternative 2A is that 2B has an operational downstream fish passage measure at Cougar Dam (deep drawdown to near the DT in spring and fall) instead of a structural measure.

This deep drawdown operation is expected to result in most juvenile Chinook salmon migrating downstream of Cougar Dam in spring, along with many resident bull trout. The deep draft in spring would also negatively affect the ability to store water in the conservation pool, resulting in lower summer stream flows and changes in water temperatures below Cougar Dam. These differences would affect fish rearing patterns both above and below Cougar Dam.

Compared to Alternative 2A, 2B would result in increased adverse effects to UWR spring Chinook salmon (moderate) and bull trout (moderate) in the McKenzie sub-basin. Otherwise, effects on listed fish species are predicted to be the same as under Alternative 2A.

Alternative 2B is more likely to effectively meet the Proposed Action ESA objectives (objectives 4-6), surpassed only by Alternative 2A. Alternative 2B ranks fourth for downstream survival with all Chinook salmon populations anticipated to reach replacement. Alternative 2B would also reduce risk to the McKenzie Core Legacy spring Chinook salmon population and would provide more habitat gains for bull trout compared to the NAA due to the inclusion of effective downstream passage at Cougar Dam.

In contrast to Alternative 2A, Alternative 2B would result in only two of the four Chinook salmon populations with high persistence. This is the primary difference in how Alternative 2B would perform for the Proposed Action ESA objectives compared to Alternative 2A This difference is a result of the downstream fish passage measure proposed at Cougar Dam. Alternative 2A proposes a FSS and Alternative 2B propose a deep drawdown to pass fish through the DT. The difference in the number of populations anticipated with high persistence is because the PEIS ESA models assume more optimistic downstream survival with a structure at Cougar Dam. It is assumed that more extreme operations, like a deep drawdown, may have adverse effects on viable populations downstream.

Alternative 2B is identical to Alternative 5 except for refinements to the “Integrated Temperature and Habitat Flow Regime” measure proposed under Alternative 5. These minor refinements to the flow operation have not undergone the ESA modeling performed on the other alternatives because the minor changes could be qualitatively described. After considering available hydrologic modeling results for Alternative 5, the different outcomes for ESA species between Alternatives 2B and 5 are considered negligible.

Structural improvements for fish passage and water temperature would provide resilience to climate change by increasing operational flexibility in the North Santiam, South Santiam, and Middle Fork sub-basins when compared the NAA with no structural improvements. See Appendix F for details on climate change effects on the WVB.

Compared to NAA, Alternative 2B would result in minor to major beneficial water temperature effects in the North Santiam, South Santiam, and South Fork McKenzie sub-basins due to the proposed temperature control structure at Detroit Dam, Green Peter Dam autumn deep drawdown with operational temperature control, and a deep drawdown at Cougar Dam.

Minor to moderate beneficial TDG effects is expected in the North Santiam and South Fork McKenzie sub-basins due to a reduced number of days with spill (at Detroit Dam, the proposed temperature control structure removed the need for operational temperature control with non-turbine outlets). Minor beneficial TDG effects are expected in the South Fork McKenzie sub-basin under Alternative 2B due to the deep drawdown at Cougar Dam that involves use of the DT, which is expected to have lower TDG than the RO. Moderate to major adverse TDG effects, when compared to the NAA, are expected in the South Santiam sub-basin due to the Green Peter Dam autumn deep drawdown that relies on more spill flow under Alternative 2B.

Under Alternative 2B, there would be an estimated decrease in total water stored by mid-May at the 75% exceedance level of 64,000 acre-feet from the NAA (1,328,542 acre-feet) primarily due to the fish passage operation at Cougar Dam. The small decrease in stored water would have a minor adverse effect to M&I water supply and AI users of the conservation storage space as compared to the NAA.

Under Alternative 2B, flow targets in the summer and fall would be met more frequently due to the additional accumulated stored water at WVS reservoirs other than Cougar and Green Peter. However, compared to the NAA, the spring and early summer flows would be similar or somewhat lower across the WVS. This would be a result of the spring drawdown at Cougar Dam that occurs during the NAA refill period.

The reduced storage at Cougar Dam would mean that other WVS reservoirs, notably in the Middle Fork of the Willamette River sub-basin, would be required to release additional water to meet mainstem Willamette River flow targets. The drawdown of the Cougar Reservoir would effectively eliminate the conservation pool for use for water supply from Cougar. However, the Blue River Reservoir would fill more than under the NAA, partially offsetting the lost storage from Cougar Reservoir.

Cougar Dam is also situated on the South Fork of the McKenzie River, and its flow is a small portion of the overall McKenzie River flow. The flow on the McKenzie River would be only slightly less as compared to the NAA due to additional flow from Blue River. Therefore, Alternative 2B would have a negligible effect to live flow water rights in the McKenzie sub-basin. Due to the expected limited level of demand for stored water on the McKenzie River, Alternative 2B would be expected to have only a minor adverse effect to M&I water supply and AI users in the McKenzie sub-basin as compared to the NAA.

The decrease in stored water would contribute to an overall decrease in average annual hydropower generation by 18 aMW (roughly enough to power 14,334 households annually see Section 3.12.3.2 for details). This, coupled with the high cost of Alternative 2B, would result in a $933 million reduction in median NPV to -$708 million. Therefore, there would be long-term, major, adverse effects on economic viability of WVS power generation under Alternative 2B as compared to the NAA.

Additionally, the fish passage operation at Cougar Dam would result in infrequent, temporary moderate adverse effects on transmission services to Blue River as compared to the NAA. Deep fall and spring drawdowns at Cougar Dam would compromise the ability to provide power to Oakridge and serve this islanded (isolated) community under temporary weather or fire related outage conditions. Generation at Hills Creek Dam would remain able to operate islanded (isolated), providing transmission services to Oakridge, like the NAA.

Alternative would 2B results in the smallest increases in annual visitations, resulting in an approximate increase of $12,000 in annual economic benefits (a 0.06% increase) compared to the NAA. Although this would be a negligible adverse effect on recreation across the WVS, the near loss of the conservation pool at Cougar Reservoir would result in major adverse effects to reservoir recreation at this location. However, the regional economic effects would similar to those under Alternative 2A because there are no jobs associated with recreation at Cougar Reservoir.

The regional economic effects would be associated with the potential loss of 1.7 jobs in the South Santiam sub-basin due to the drawdown at Green Peter Dam and a moderate reduction in regional output as compared to the NAA.

Alternative 2B would be the fourth costliest alternative to implement (surpassed by Alternatives 1, 2A, and 4) due to the incorporation of numerous structural measures. The estimated total annual cost for Alternative 2B is $62,291 million, $53 million greater than the NAA (see Appendix M for details).

The higher design costs compared to Alternative 2A is because the modification of the DT required to perform the fish passage operation at Cougar Dam under Alternative 2B would require new construction. The Cougar Dam FSS proposed under Alternative 2A has already undergone detailed design and would require limited additional design effort compared to Alternative 2B. Conversely, the annual O&M cost for Alternative 2B would be lower than under Alternative 2A because the FSS would require substantially more O&M than operation of the DT once it is constructed.

Although Alternative 2B would be beneficial for meeting the Proposed Action ESA objectives, during the tradeoffs analyses with input from USFWS and NMFS, USACE deemed Alternatives 2A, 2B, and 5 too similar to effectively differentiate between their effects on ESA-listed species. Additionally, Alternative 2A would have higher uncertainty in meeting Proposed Action ESA objectives at Cougar Dam as compared to Alternatives 2B and 5. In contrast, there is high confidence that when reservoirs are drafted very low, juvenile Chinook salmon would successfully pass downstream under Alternative 2B (NMFS, 2014).

In addition to the assumption that more extreme operations, like a deep drawdown, may have adverse effects on viable populations downstream, the main risk associated with Alternative 2B relates to modifications required to operate the DT. The DT was originally constructed to be used temporarily during dam construction and was not designed to be operated on a regular basis. Without detailed investigation and designs, the dam safety and operational feasibility of drawing down to the DT annually for fish passage is uncertain. However, unlike the FSS, which would have limited mitigation actions available for addressing the fish collection risks with current technology, there are clear engineering pathways for managing risk associated with dam safety and operational feasibility of a dam outlet.

In sum, Alternative 2B would effectively meet the Proposed Action ESA objectives at lower risk and substantially lower costs than under Alternative 2A. However, Alternative 2B was not chosen as the Preferred Alternative because discussions with cooperators revealed refinements to the "Integrated Temperature and Habitat Flow Regime" operation that could result in increased comparative beneficial effects on listed fish species. Subsequently, these refinements were included under Alternative 5, the Preferred Alternative and are not included under the NAA. Alternative 2B is identical to Alternative 5 but for these refinements to the "Integrated Temperature and Habitat Flow Regime" measure.

#### *5.2.7.5 Alternative 3A. Improve Fish Passage Through Operations-focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Regulating Outlet)*

Alternatives 3A, also referred to as the Operations-focused Fish Passage Alternative, would primarily utilize WVS dam operations for water quality and fish passage. As under the NAA, Alternative 3A would not include structural measures for temperature control, TDG abatement, or downstream fish passage like Alternatives 1 and 4 and much of Alternatives 2A, 2B, and 5.

An important part of the operational focus under Alternative 3A, and a distinction from the NAA, would be the increased use of different flow outlets from the dams to control temperature, with the spillway supplying warmer water from the upper reservoir and the deeper outlets – ROs and turbines – supplying cooler water. Alternative 3A would also implement spring and fall drawdowns at some WVS reservoirs for volitional downstream fish passage, which would not occur under the NAA. Additionally, where Alternative 1, 2A, 2B, 4, and 5 only proposed a new adult fish facility for upstream fish passage at Green Peter Dam, Alternative 3A proposes new adult fish facilities at Hills Creek and Blue River Dams as well. No new fish facilities are proposed under the NAA.

Table 5.2-6 shows the major operational and structural features of Alternative 3A.

**Table 5.2-6. Water Quality and Passage Measures Under Alternative 3A.**

| Dam | Temperature Control | TDG structural Improvements | Downstream Fish Passage | Upstream Fish Passage |
|---|---|---|---|---|
| Dexter | – | – | Operational – use spillway* | – |
| Lookout Point | Operational – spillway and RO releases* | – | Operational – spring and fall drawdown* | – |
| Hills Creek | Operational – spillway releases* | – | Operational – use spillway and fall drawdown* | Structural* |
| Fall Creek | – | – | Operational – use spillway* | – |
| Cougar | – | – | Operational – spring and fall | – |

| Dam | Temperature Control | TDG structural Improvements | Downstream Fish Passage | Upstream Fish Passage |
|---|---|---|---|---|
| | | | drawdown (RO)* | |
| Blue River | Operational – spillway releases* | – | Operational –fall drawdown* | Structural* |
| Foster | Operational – spillway releases* | – | – | – |
| Green Peter | Operational – spillway and RO releases* | – | Operational – use spillway and fall drawdown* | Structural |
| Big Cliff | – | – | Operational – use spillway* | – |
| Detroit | Operational – spillway and RO releases* | – | Operational – spring and fall drawdown* | – |

*Distinctive feature of this alternative.

Alternative 3A is very similar to Alternative 3B, with proposed differences in downstream fish passage operations in spring as shown in Table 5.2-7. Alternatives 3A and 3B also differ in the proposed drawdowns for fish passage operations at Cougar Dam.

Under Alternative 3A, the spring and fall drawdowns would target the Cougar Dam RO, whereas the Alternative 3B drawdowns would target the much lower DT (like Alternatives 2B and 5). By making these distinctions between Alternatives 3A and 3B, the unique effects associated with each of these operations for downstream passage to be identified at Cougar Dam and the tradeoffs between them can be assessed and compared.

**Table 5.2-7. Differences in Spring Downstream Fish Passage Operations between Alternatives 3A and 3B.**

| Dam | Spring Drawdown | Spring Spill |
|---|---|---|
| DEX | – | 3A & 3B |
| LOP | 3A | 3B |
| HCR | 3B | 3A |
| FCR | – | 3A |
| CGR | 3A- RO, 3B DT | – |
| BLU | – | – |
| FOS | – | – |
| GPR | 3B | 3A |
| BCL | – | 3A & 3B |
| DET | 3A | 3B |

Under Alternative 3A and Alternatives 2B, 3A, 3B, and 4, the "Integrated Temperature and Habitat Flow Regime" operation replaces the 2008 BiOp flows under the NAA. Alternative 3A would also augment instream flows by using the power and inactive pools and allows reservoirs to draft below the NAA rule curves to meet minimum flow requirements. This would usually occur during the fall of drier years at reservoirs that do not have a fall drawdown operation.

###### *5.2.2.5.1 Tradeoffs*

Alternative 3A has an operational theme (i.e., fish passage, water quality and other missions are accomplished by operation of existing structures). Unlike operations under the NAA, deep reservoir drawdowns would occur in spring and fall at Detroit, Cougar (to RO), and Lookout Dams. Spring surface spill and fall deep drawdowns would occur at Green Peter and Hills Creek Dams. A fall deep drawdown at Fall Creek would continue as under the NAA.

Alternative 3A would have major adverse effects for UWR spring Chinook salmon and UWR steelhead. Predicted performance for these species is very similar to those under the NAA, with some improvement in North Santiam Chinook salmon and South Santiam steelhead populations. Similarly, Alternative 3A would have major adverse effects for bull trout. Reservoir rearing area would be substantially reduced in both Detroit and Cougar Reservoirs. Consequently, bull trout would be expected to increase movement into more degraded rearing habitat below Detroit and Hills Creek Dams where spawning habitat does not exist, and human disturbance is high.

Alternative 3A would not effectively meet all the Proposed Action ESA objectives. Although all four Chinook salmon populations would reach replacement under Alternative 3A, only one out of four Chinook salmon populations would have high persistence (e.g., low risk of extinction), which would not be an improvement as compared to the NAA. Additionally, Alternative 3A ranks fifth for downstream survival, and the McKenzie Core Legacy spring Chinook salmon population is at risk of extinction. However, there would be habitat gains for bull trout as compared to the NAA.

Climate change is predicted to further degrade habitat for bull trout below dams and will reduce the ability to meet operational fish passage, minimum flows, and water temperature targets below dams for UWR spring Chinook salmon and UWR steelhead. See Appendix F for details on climate change effects on the WVB.

Compared to the NAA, Alternative 3A would result in minor to major beneficial water temperature effects in the Middle Fork Willamette (between Hills Creek Dam and Lookout Point Dam) and South Santiam sub-basins due to the proposed deep drawdowns at Hills Creek and Green Peter Dams. In the North Santiam sub-basin, minor beneficial effects to water temperature are expected during the autumn while moderate adverse effects are expected during the spring-summer due to deep drawdown at Detroit Dam under Alternative 3A. In the South Fork McKenzie sub-basin, minor adverse effects to water temperature are expected during the fall due to a partial drawdown at Cougar Dam under Alternative 3A. Minor to major adverse TDG effects are expected in the North Santiam, South Santiam, and Middle Fork

Willamette sub-basins due to the deep drawdowns at Detroit, Green Peter (autumn) and Lookout Point Dams that rely on high outflows and/or spill flow under Alternative 3A.

By combining spring spill and drawdowns with fall drawdowns at 6 of the 11 storage projects, Alternative 3A would substantially affect the ability to refill the system-wide conservation storage. These operations would result in a 56% reduction of system-wide stored water compared to the NAA, or 590,000 acre-feet. Depending on how and when the Fish and Wildlife conservation storage allocation is takes priority over other consumptives uses it would leave very little conservation storage available for M&I water supply or AI. Therefore, Alternative 3A would have a major adverse effect to M&I water supply and irrigation.

Additionally, under Alternative 3A, flows during dry years would be lower than under the NAA starting in April, dropping below 5,000 cfs in August at Salem. This would likely cause water users in the system to be shut off more than under current conditions, resulting in a moderate adverse effect to M&I water supply and AI as compared to the NAA.

The decrease in stored water would contribute to an overall decrease in average annual hydropower generation by 87 aMW (roughly enough to power 69,283 households annually; see Section 3.12.3.2 for details). Coupled with the cost of Alternative 3A, there would be a $853 million reduction in median NPV to -$628 million. Therefore, long-term, major, adverse effects on the economic viability of WVS power generation would occur under Alternative 3A as compared to the NAA.

Additionally, the fish passage operations at Hills Creek and Cougar Dams would result in infrequent, temporary moderate adverse effects on transmission services to Oakridge and Blue River. Deep fall and spring drawdowns would compromise abilities to serve these communities from Hills Creek and Cougar Dams under temporary storm or fire related outage conditions which would not occur under the NAA where power generation would not be impacted.

Alternative 3A is one of two alternatives that would result in decreases in annual visitations as compared to the NAA. This would be a major, long-term adverse effect to recreation in the WVS, resulting in an approximate decrease of $769,000 in annual economic benefits (a 3.76% decrease) compared to the NAA.

The effects to recreation would also have a high regional economic impact with close to a 50% reduction in recreation-related jobs in the North Santiam (14 jobs lost) and Middle Fork Willamette (13.7 jobs lost) sub-basins and a reduction in regional output greater than $150,000 in multiple basins.

Alternative 3A would be the least costly alternative to implement because it incorporates the fewest structural measures. Alternative 3A would be approximately $86 million less annually than the costliest alternative, Alternative 4. The estimated total annual cost for Alternative 3A is $26,442 million, $17 million greater than the NAA (see Appendix M for details).

Although one of the least costly alternatives, Alternative 3A would perform poorly for Proposed Action ESA objectives while substantially decreasing water stored in the conservation pools with adverse effects to hydropower, water supply, and recreation. Additionally, the autumn deep and spring drawdowns would compromise the abilities to serve nearby communities from Hills Creek and Cougar Dams under temporary storm or fire related outage conditions. These adverse effects without appreciable benefits for ESA-listed species makes it unlikely this alternative would be acceptable to stakeholders, agencies, and the public. Therefore, Alternative 3A was not identified as the Preferred Alternative.

#### *5.2.7.6 Alternative 3B. Improve Fish Passage Through Operations-focused Measures (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel)*

Alternatives 3B, also referred to as the Operations-focused Fish Passage Alternative using Diversion Tunnel at Cougar, would primarily utilize WVS dam operations for water quality and fish passage. Table 5.2-8 shows the major operational and structural features of Alternative 3B.

Alternative 3B is very similar to Alternative 3A, with differences in downstream fish passage operations in spring as shown in Table 5.2-7. Alternatives 3A and 3B also differ in the drawdowns for fish passage operations at Cougar Dam. Under Alternative 3B, the spring and fall drawdowns would target the DT (like Alternatives 2B and 5), resulting in a much lower drawdown than Alternative 3A, which proposes drawing down only to the RO. By making these distinctions between Alternatives 3A and 3B, the unique effects associated with each of these operations for downstream passage to be identified at Cougar Dam and the tradeoffs between them can be assessed and compared.

**Table 5.2-8. Water Quality and Passage Measures Under Alternative 3B.**

| Dam | Temperature Control | TDG structural Improvements | Downstream Fish Passage | Upstream Fish Passage |
|---|---|---|---|---|
| Dexter | – | – | Operational – use spillway* | – |
| Lookout Point | Operational – spillway and RO releases* | – | Operational – use spillway and fall drawdown* | – |
| Hills Creek | Operational – spillway releases* | – | Operational – spring and fall drawdown* | Structural* |
| Fall Creek | – | – | – | – |
| Cougar | – | – | Operational – spring and fall drawdown (DT)* | – |
| Blue River | Operational – spillway releases* | – | Operational – fall drawdown* | Structural* |

| Dam | Temperature Control | TDG structural Improvements | Downstream Fish Passage | Upstream Fish Passage |
|---|---|---|---|---|
| Foster | Operational – spillway releases* | – | – | – |
| Green Peter | Operational – spillway and RO releases* | – | Operational – spring and fall drawdown* | Structural |
| Big Cliff | – | – | Operational – use spillway* | – |
| Detroit | Operational – spillway and RO releases | – | Operational – use spillway and fall drawdown | – |

*Distinctive feature of this alternative.

##### *5.2.2.6.1 Tradeoffs*

Alternative 3B also has an operational theme, with a different combination of fish passage measures than 3A or the NAA. Deep reservoir drawdowns would occur in spring and fall at Green Peter, Cougar (to DT), and Hills Creek Dams. Spring surface spill and fall deep drawdowns would occur at Detroit and Lookout Point Dams. A fall deep drawdown at Fall Creek Dam would continue as under the NAA.

Alternative 3B would have moderate to major adverse effects on UWR spring Chinook salmon and UWR steelhead. Alternative 3B would have moderate to major adverse effects for bull trout. Reservoir rearing area is substantially reduced in Cougar Reservoir, and passage would result in increased movement into more degraded rearing habitat below Detroit and Hills Creek Dams where spawning habitat does not exist, and human disturbance is high.

Alternative 3B would not effectively meet all the Proposed Action ESA objectives (objective 4-6). Under Alternative 3B, all four Chinook salmon populations would reach replacement and two out of four Chinook salmon populations would have high persistence (e.g., low risk of extinction). However, Alternative 3B ranks sixth for downstream survival (the lowest ranking of the action alternatives) though it is still an improvement over the NAA. Additionally, the McKenzie Core Legacy spring Chinook salmon population is at risk of extinction, and there would be no habitat gains for bull trout as compared to the NAA.

As under the NAA, climate change is predicted to further degrade habitat for bull trout below dams and will reduce the ability to meet operational fish passage, minimum flows, and water temperature targets below dams for Chinook salmon and steelhead. See Appendix F for details on climate change effects on the WVB.

Compared to NAA, Alternative 3B would result in minor to moderate beneficial water temperature effects in the Middle Fork Willamette, McKenzie, and South Santiam sub-basins due to the proposed drawdowns at Hills Creek, Lookout Point, Cougar, and Green Peter Dams.

Minor to major adverse TDG effects would be expected in the North Santiam, South Santiam, and Middle Fork Willamette sub-basins (below Dexter Dam) due to the deep drawdowns at Detroit (autumn), Green Peter, and Lookout Point Dams (autumn) that rely on high outflows, thereby increasing the number of days with spill under Alternative 3b as compared to the NAA or action alternatives with structural improvements for TDG like alternatives 1 and 4. Minor beneficial TDG effects are expected in the South Fork McKenzie sub-basin under Alternative 3B due to the deep drawdown at Cougar Dam that would involve use of the DT, which is expected to have lower TDG than the RO.

By combining spring spill and drawdowns with fall drawdowns at 6 of the 11 storage projects, Alternative 3B would substantially affect the ability to store water system-wide. These operations would result in a 50% reduction of water stored system-wide compared to the NAA, or 669,000 acre-feet. Depending on how and when the Fish and Wildlife conservation storage allocation is takes priority over other consumptives uses it would leave very little conservation storage available for M&I water supply or AI. Therefore, Alternative 3B would have a major adverse effect to M&I water supply and irrigation.

Unlike Alternative 3A, the goal under Alternative 3B is to fill Detroit Reservoir for a spring spill fish passage operation; hence flows at Salem in Alternative 3B would rarely drop below 5,000 cfs in the summer, though they would be lower than under the NAA in dry years. Alternative 3B includes a spring drawdown at Hills Creek Dam instead of Lookout Point Dam, so water flowing through Hills Creek Dam can be stored in Lookout Point Dam, which would preserve a larger amount of water than under Alternative 3A.

The decrease in stored water would contribute to an overall decrease in average annual hydropower generation by 79 aMW (roughly enough to power 62,912 households annually; see Section 3.12.3.2 for details). This, coupled with the cost of Alternative 3B, would result in a $829 million reduction in median NPV to -$604 million. Therefore, there would be long-term, major, adverse effects on economic viability of WVS power generation under Alternative 3B as compared to the NAA.

Additionally, the fish passage operations at Hills Creek and Cougar Dams would result in infrequent, temporary moderate adverse effects on transmission services to Oakridge and Blue River. Deep fall and spring drawdowns would compromise abilities of Hills Creek and Cougar Dams to operate islanded and to serve these communities under temporary storm or fire related outage conditions, which would not occur under the NAA.

Alternative 3B would result in the largest decreases in annual visitations. This would be a major, long-term adverse effect to recreation in the WVS, resulting in an approximate decrease of $1,274,000 in annual economic benefits (a 6.23% decrease) compared to the NAA. The effects to recreation would also have a high regional economic impact with a 50% reduction in recreation related jobs in the South Santiam sub-basin and a reduction in regional output greater than $150,000 in multiple basins.

Alternative 3B would be the second least costly alternative to implement due to incorporation of few structural measures. Alternative 3A would be the only less costly alternative in comparison. This is because Alternative 3B includes a lower drawdown operation at Cougar Dam that requires additional costs to modify the DT, as discussed under the Alternative 2B tradeoffs which also has a fish passage measure utilizing the DT at Cougar. The estimated total annual cost for Alternative 3B is $30,652 million, $21 million greater than the NAA (see Appendix M for details).

Although one of the least costly alternatives, Alternative 3B would perform poorly for Proposed Action ESA objectives while substantially decreasing water store system-wide with adverse effects to hydropower, water supply, and recreation. Additionally, the deep fall and spring drawdowns would compromise abilities of Hills Creek and Cougar Dams to serve nearby communities under temporary storm or fire related outage conditions. These adverse effects without appreciable benefits for ESA-listed species makes it unlikely this alternative would be acceptable to stakeholders, agencies, and the public. Therefore, Alternative 3B was not identified as the Preferred Alternative.

#### *5.2.7.7 Alternative 4. Improve Fish Passage with Structures-based Approach*

Alternative 4 takes a structures-based approach to improve fish passage through the WVS dams to increase the survival of ESA-listed fish. In contrast to the NAA but as under Alternative 1, Alternative 4 proposes only structures for water quality and downstream fish passage, shifting the release of stored water from the spring into the summer and fall and augmenting instream flows by using the power and inactive pools.

Also, in contrast to the NAA and Alternative 1, Alternative 4 proposes the “Integrated Temperature and Habitat Flow Regime” operation, the targets of which are generally higher and more variable than those in the congressionally authorized minimum flow requirements proposed under Alternative 1. Alternative 4 also proposes the most structural measures for fish passage and water quality of any alternative as shown in Table 5.2-90.

**Table 5.2-9. Key measures under Alternative 4.**

| Dam | Temperature Control | TDG Improvements | Downstream Fish Passage | Upstream Fish Passage |
|---|---|---|---|---|
| Dexter | – | Structural* | – | – |
| Lookout Point | Structural | – | Structural | – |
| Hills Creek | Structural* | – | Structural* | Structural* |
| Fall Creek | – | – | – | – |
| Cougar | – | Structural* | Structural* | – |
| Blue River | – | – | – | – |
| Foster | Structural | Structural* | Structural | – |
| Green Peter | Operational* | Structural* | – | – |
| Big Cliff | – | – | – | – |

| Dam | Temperature Control | TDG Improvements | Downstream Fish Passage | Upstream Fish Passage |
|---|---|---|---|---|
| Detroit | Structural | – | Structural | – |

*Distinctive feature of this alternative.

In contrast to the NAA and Alternative 1, Alternative 4 would include a fish passage structure and WTC tower at Hills Creek Dam and a fish passage structure at Cougar Dam. Alternative 4 also replaces the WTC tower at Green Peter Dam proposed under Alternative 1 with using operational measures utilizing the spillway and ROs for temperature management. In contrast to the NAA and Alternatives 1, 2A, 2B, and 5, Alternative 4 proposes an upstream passage structure at Hills Creek Dam and not at Green Peter Dam. These differences allow for the comparison of the relative costs and benefits associated with the different combinations of structural measures.

*5.2.2.7.1 Tradeoffs*

Alternative 4 is a structural focused alternative and includes large floating fish passage structures coupled to temperature structures in the North, McKenzie and the Middle Fork sub-basins. Smaller structures are included at Foster Dam in the South Santiam. A fall deep drawdown at Fall Creek would continue as under the NAA.

Under Alternative 4, adverse effects are predicted to be moderate for UWR spring Chinook salmon, minor for UWR winter steelhead, and moderate for bull trout. Habitat scoring for bull trout would be improved in all three sub-basins due to passage actions as compared to the NAA. However, access to below-dam habitat would increase demographic risks especially below Hills Creek Dam and below Detroit Dam where human disturbance is higher. By increasing the number of bull trout passing downstream and becoming exposed to these disturbances compared to the NAA, there is an increase in demographic risk.

Despite the greatest spending on structural measures for ESA-listed species needs, Alternative 4 would not perform the best for meeting Proposed Action ESA objectives (objectives 4-6). Like Alternative 1, although Alternative 4 ranks moderately well for downstream survival (third), and three out of four Chinook salmon populations would reach replacement; only two out of four Chinook salmon populations would have high persistence (e.g., low risk of extinction). In contrast to Alternative 1, Alternative 4 would reduce risk to the McKenzie Core Legacy spring Chinook salmon population and would provide more habitat gains for bull trout compared to the NAA due to the inclusion of effective downstream passage at Cougar Dam. Alternative 2A would perform better than Alternative 4 for the replacement, persistence, and downstream survival metrics and Alternatives 2B and 5 for the replacement metrics.

Structural improvements for fish passage and water temperature would provide resilience to climate change by increasing operational flexibility in the North Santiam, South Santiam, Middle Fork sub-basins, as compared to the NAA. See Appendix F for details on climate change effects on the WVB.

Compared to NAA, Alternative 4 would result in minor to major beneficial water temperature effects in the Middle Fork Willamette sub-basin (between Hills Creek Dam and Lookout Point Dam), South Santiam, and North Santiam sub-basins due to the proposed temperature control structures at Hills Creek, Lookout Point, and Detroit Dams as well as operational temperature control at Green Peter Dam. Minor to major beneficial TDG effects are expected in the North Santiam and South Fork McKenzie sub-basins based on the proposed TDG abatement structures below Detroit and Big Cliff Dams and the reduced number of spill days at Cougar Dam under Alternative 4.

Under Alternative 4, as under Alternative 2A, there would be an estimated increase in water stored system-wide at the 75% exceedance level of 122,000 acre-feet from the NAA. The combination of lower spring flow targets and no reservoir drawdowns during the conservation season would allow for the increase from the NAA in stored water. The increased stored water would likely result in a moderate beneficial effect to municipal and industrial water supply and AI users of the conservation storage space.

The Integrated Flow Regime would include additional flow based on the air temperature, compared to the 2008 BiOp flows implemented under the NAA. Therefore, flows later in the summer and fall would be higher than the NAA due to the additional accumulated stored water.

The additional stored water would contribute to an overall slight increase in average annual hydropower generation by 1 aMW (roughly enough to power 796 households annually; see Section 3.12.3.7 for details). However, the high capital and O&M cost of Alternative 4 would result in the second greatest decrease in NPV from that provided by the NAA.

Under Alternative 4, there would be a $1.162 billion reduction in median NPV to -$937 million. Therefore, there would be long-term, major, adverse effects on economic viability of WVS power generation. There would also be negligible risk to local hydropower generation as Hills Creek and Cougar Dams would continue to be able to operate islanded (isolated) from the rest of the power system, providing power to the communities of Oakridge and Blue River, respectively, during power system outages due primarily to weather events or fires.

Under Alternative 4, the additional stored water would mean the reservoirs stay higher for more of the conservation season as compared to the NAA, resulting in minor to moderate benefits to reservoir recreation. This would translate into slight increases in annual visitations, resulting in an approximate increase of $167,000 in annual economic benefits (a 0.82% increase) compared to the NAA.

The regional economic impact from recreation effects would be medium. The regional economic effects would be associated with a moderate reduction in regional output and the potential loss of 1.7 jobs in the South Santiam and McKenzie sub-basins due to the drawdown at Green Peter and operations at Blue River Dam.

Alternative 4 would be the costliest alternative to implement, primarily driven by the cost to design, construct, operate, and maintain the structural measures for temperature control, fish passage, and TDG abatement. Alternative 4 proposes the most structural measures of any alternative. The estimated total annual cost for Alternative 4 is $113,001 million, $104 million greater than the NAA (see Appendix M for details).

Due to the scale of the measures under Alternative 4, which are largely structural this would be the most expensive alternative. The high cost makes it unlikely this alternative would be acceptable to many stakeholders, agencies, and the public. This is compounded by the fact that Alternative 4 would result in fewer benefits to ESA species than several less costly alternatives, including Alternatives 2A, 2B, and 5. Therefore, Alternative 4 was not identified as the Preferred Alternative.

#### *5.2.7.8 Alternative 5. Refined Integrated Water Management Flexibility and ESA-listed Fish Alternative (Includes Operational Downstream Passage at Cougar – Drawdown to Diversion Tunnel) - Preferred Alternative*

Alternative 5, also referred to as the Refined Hybrid Alternative with Cougar Diversion Tunnel Modification, is the same as Alternative 2B except for the proposed flow regime. Alternative 5 was ultimately selected by the Corps as the preferred alternative. This alternative was the most successful at finding a balance between cost and meeting the proposed action ESA objectives.

The flow operation proposed under Alternative 5 is a modified version of the "Integrated Temperature and Habitat Flow Regime" proposed under all action alternatives except for Alternative 1 and the NAA.

Following discussions with cooperators on how the "Integrated Temperature and Habitat Flow Regime" could be improved to better meet the species needs during the lowest low flows, USACE refined the flow operation, which is incorporated into Alternative 5. As shown in Section 3.2.2.10, the key difference of the refined flow operation would be higher flows at Foster, Detroit, and Cougar Dams as compared to the NAA and the other action alternatives.

The refinement for Cougar Dam flows would be much smaller, however, because the drawdown operation to the DT for fish passage results in much less storage compared to Foster and Detroit Dams to supplement flow. Additionally, the mainstem Willamette River flows would have different flow levels reflective of a basin-wide hydrology forecast.

Table 5.2-10 shows the major operational and structural features of Alternative 5.

**Table 5.2-10 . Water Quality and Passage Measures Under Alternative under Alternative 5.**

| Dam | Temperature Control | TDG structural Improvements | Downstream Fish Passage | Upstream Fish Passage |
|---|---|---|---|---|
| Dexter | – | – | – | – |
| Lookout Point | – | – | Structural | – |
| Hills Creek | – | – | – | – |
| Fall Creek | – | – | – | – |
| Cougar | – | – | Operational * | – |
| Blue River | – | – | – | – |
| Foster | Structural | – | Structural | – |
| Green Peter | Operational* | – | Operational* | Structural* |
| Big Cliff | – | – | – | – |
| Detroit | Structural | – | Structural | – |

*Distinctive feature of this alternative.

*5.2.2.8.1 Tradeoffs*

The tradeoffs under Alternative 5 are the same as those discussed under Alternative 2B except that Alternative 5 would have a greater reduction by $6 million in NPV compared to Alternative 2B. Under Alternative 5, there would be a $939 million reduction in median NPV to -$714 million as compared to the NAA. The effects to UWR spring Chinook salmon, UWR steelhead, and bull trout would be the same under Alternative 5 as under Alternative 2B.

As discussed, Alternative 5 is identical to Alternative 2B except for refinements to the "Integrated Temperature and Habitat Flow Regime" measure. Despite refinements to the "Integrated Temperature and Habitat Flow Regime" measure, little to no difference between Alternative 2B and 5 is predicted regarding reservoir volumes or flows below dams, since reservoir drafting during the conservation season and early flood seasons would result in stream flows remaining above minimums. Therefore, these refinements to the flow operation have no to negligible change to the outcomes as described under Alternative 2B for hydropower, water supply, and recreation.

Alternative 5 has been identified as the Preferred Alternative by USACE. Like Alternative 2B, Alternative 5 would meet the Proposed Action ESA objectives. During the tradeoffs analyses, with input from cooperators, USACE deemed the effects on ESA listed species under Alternatives 2A, 2B, and 5 to be so similar that it was difficult to differentiate between them on that basis, however they are all an improvement for ESA species given the fish passage, flow, and water quality measures as compared to the NAA.

As discussed in the evaluation of Alternatives 2A and 2B, Alternative 5 would effectively meet the Proposed Action ESA objectives (objectives 4-6) at lower risk and substantially lower costs than Alternative 2A,1, or 4. Alternative 5 was chosen as the Preferred Alternative due to the flow operation refinements and subsequent beneficial effects that resulted from engagement with cooperators.

## 5.3 SUMMARY OF THE PREFERRED ALTERNATIVE

The Preferred Alternative is Alternative 5 as described in Section 2.4.9 of the PEIS. The Preferred Alternative contains a variety of structural and operational measures to meet the Proposed Action objectives developed for the PEIS. The measures are intended to improve conditions for ESA-listed fish while providing more flexible ways for USACE to meet demands for fish and wildlife, FRM, water supply for M&I, water quality, water supply, irrigation, hydropower generation, and recreation in the Willamette River Basin (WRB). This alternative was the most successful at finding a balance costs, impacts and the Proposed Action's ESA objectives.

The Preferred Alternative includes the measures that USACE would implement over the 30-year implementation period as well as monitoring and evaluation as described in the Adaptive Management Plan (AMP). Sections 5.4 and 5.5 summarize how the Preferred Alternative would be executed under the Implementation Plan and AMP, respectively. Appendix N provides a more detailed description of implementation and adaptive management of the Preferred Alternative.

Additionally, as described in Section 2.2.5, USACE is proposing to continue a suite of near-term operations until structural measures in the preferred alternative are operational. When all the measures in the Preferred Alternative are implemented, any remaining near-term operations will cease. How and when an operation at a location is superseded or replaced by measure in the Preferred Alternative is described in the Implementation Plan. If the Preferred Alternative is refined or changes as a result of the ongoing ESA consultation or as a result of comments from the public on the draft PEIS a new implementation plan would be developed for that alternative.

## 5.4 IMPLEMENTATION PLAN

The Implementation Plan (provided in Appendix N) is a companion document to the WVS EIS. It describes the implementation sequencing of the measures in the Preferred Alternative. This plan links immediate operations to improve fish passage and water quality (e.g., Near-term Operations measure) to the longer-term structural measures, such as the downstream fish passage construction projects, and identifies check-ins, or points along the implementation timeline where course correction (i.e., "on-ramps/off-ramps") may be necessary based on research, monitoring, and evaluation (RM&E). Any change would be evaluated for any additional NEPA or environmental compliance that would be necessary.

The Implementation Plan is considered a roadmap or high level, tentative schedule that lays out a strategy and plan for implementation of the measures developed through the PEIS process. Considerations such as basin-wide priorities, risk and uncertainty, research and development, and research, monitoring, and evaluation of data gaps and other factors have been used to shape this plan and to develop a schedule that is both reasonable and implementable given the information available to USACE at present.

### 5.4.1 Preferred Alternative Implementation and Replacement of the Near-term Operations Timeline

Figure 5.4-1 provides the proposed implementation timeline of the operations and construction of the structural measures in the Preferred Alternative. This implementation timeline is highly dependent on the timing of design and construction funding (i.e., when this funding becomes available).

In Figure 5.4-1, the check-in stars indicate when USACE will evaluate the effectiveness of the measure and determine if changes should be made based on the framework for addressing such changes in the AMP. For instance, there is currently uncertainty that the FSS structural downstream passage measures proposed at some dams would be effective. The check-ins will provide opportunities to refine future designs based on information and lessons learned from other recently constructed similar structures.

The PEIS environmental consequences analyses assumed all operations in the Near-term Operations Measure would be in place for the duration of the 30-year PEIS period of analysis to capture the full the effects of these operations, given the difficulty and uncertainty in implementing these large-scale construction projects. While uncertain, Table 5.4-1 summarizes what measure under the Preferred Alternative would replace each operation at a specific location in the Near-term Operations Measure and provides the best-case scenario date for when each would be replaced, which is based on USACE’s experience in constructing these large scale projects.

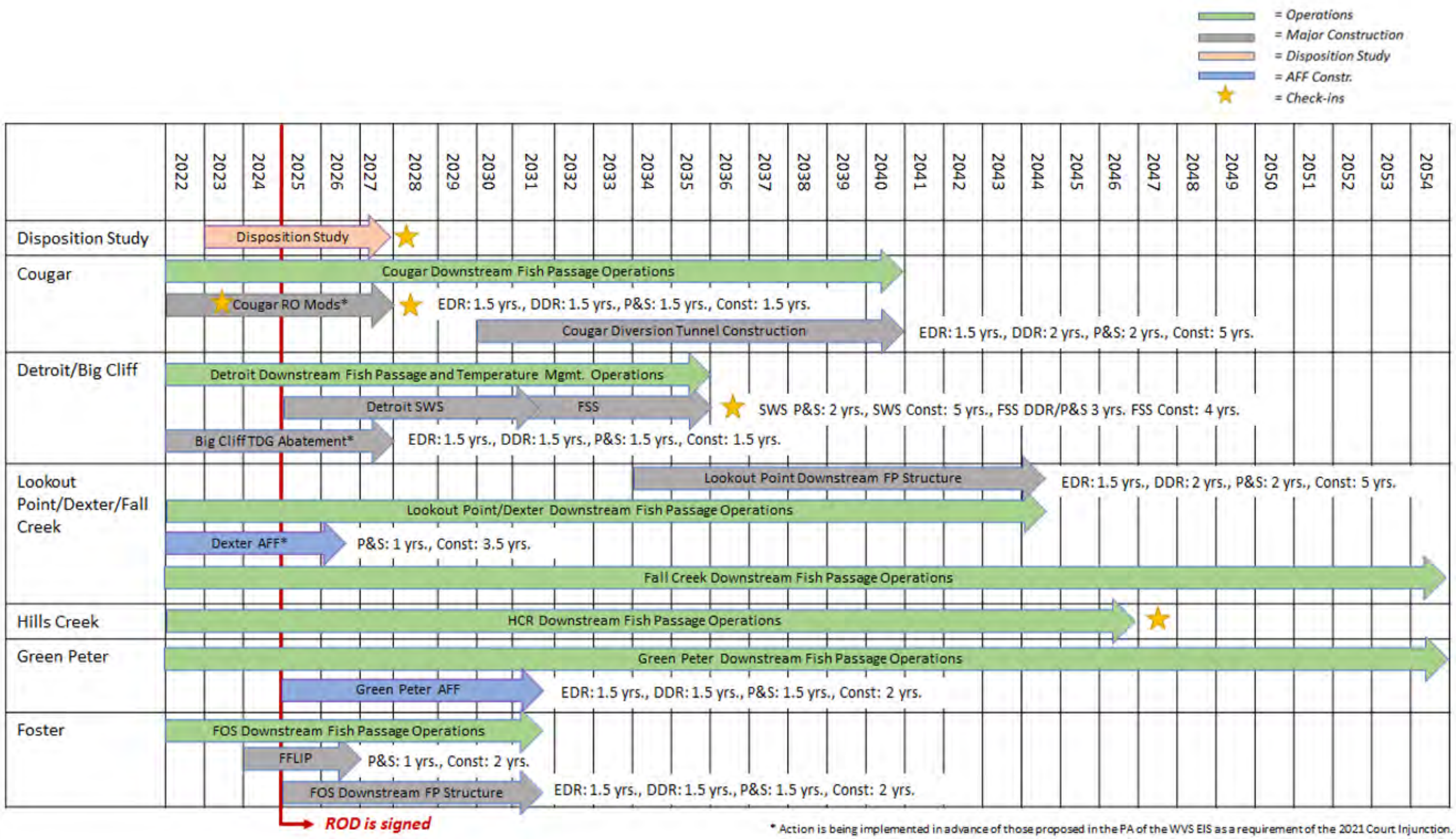


**Figure 5.4-1. Best-Case Scenario for the Preferred Alternative Implementation Timeline (funding-dependent)**

**Table 5.4-1. Base-case scenario timeline for replacing the Preferred Alternative Measures to replace Near-term Operation**

| Dam | Near-term Operation | Preferred Alternative Measure(s) to Replace Near-term Operation | Approximate Replacement Year |
|---|---|---|---|
| Detroit | Spring downstream fish passage and operational downstream temperature management | 105. Construct water temperature control tower<br><br>392. Construct structural downstream fish passage | 2031<br><br>2035 |
| Detroit | Nighttime RO prioritization for improved downstream fish passage | 392. Construct structural downstream fish passage | 2035 |
| Big Cliff | Spread spill across spillbays to reduce downstream TDG exceedances | This operation would continue until the TDG structural solution is constructed as required by the injunction. | 2027 |
| Green Peter | Outplanting plan for the reintroduction of adult Chinook salmon above Green Peter Dam | 722. Construct adult fish facility | 2031 |
| Green Peter | Utilize spillway for improved downstream fish passage in the spring; perform spill operation until 01 May or for 30 days, whichever is longer | 721. Use spillway for surface spill in summer | 2025 |
| Green Peter | Deep drawdown and RO prioritization for improved downstream fish passage | 40. Deeper fall reservoir drawdowns for downstream fish passage | 2025 |
| Foster | Delay refill and utilize spillway in the spring for improved downstream fish passage.<br><br>Use the fish weir in the summer for improved downstream temperature management and upstream fish migration/passage | 392. Construct structural downstream fish passage<br><br>479. Foster Fish Ladder Temperature Improvement | 2031<br><br>2027 |
| Foster | Utilize the spillway for improved downstream fish passage in the fall | 392. Construct structural downstream fish passage | 2031 |
| Cougar | Deep drawdown and RO prioritization for improved downstream fish passage | 40. Deeper fall reservoir drawdown to the DT for downstream fish passage | 2041 |
| Cougar | Delayed reservoir refill and RO prioritization for improved downstream fish passage | 40. Deeper fall reservoir drawdown to the DT for downstream fish passage | 2041 |

| Dam | Near-term Operation | Preferred Alternative Measure(s) to Replace Near-term Operation | Approximate Replacement Year |
|---|---|---|---|
| Hills Creek | Nighttime RO prioritization for improved downstream fish passage | This operation would continue until the check-in. At which point USACE would evaluate if changes should be made per the AMP. | 2047–Check-in |
| Lookout Point | Utilize spillway for improved downstream fish passage in the spring; RO use in the fall for downstream temperature management | 392. Construct structural downstream fish passage | 2044 |
| Lookout Point | Deep drawdown and RO prioritization for improved downstream fish passage | 392. Construct structural downstream fish passage | 2044 |
| Fall Creek | Deep drawdown and RO prioritization for improved downstream fish passage | This operation would continue for the duration of the 30-year period of analysis. | 2054 |
| Fall Creek | Delayed reservoir refill and RO prioritization for improved downstream fish passage | This operation would continue for the duration of the 30-year period of analysis. | 2054 |

## 5.5 ADAPTIVE MANAGEMENT PLAN

The Adaptive Management Plan (AMP) is also a companion document to the WVS PEIS (Appendix N). The AMP outlines the governance[63] framework to be used for adaptive decision-making, the annual adaptive management process for engaging with stakeholders, and the process to incorporate new learning into management priorities. The AMP also outlines the decision criteria relevant to monitoring and evaluating the success of management measures at achieving stated objectives.

USACE's adaptive management technical guide defines adaptive management (AM) as a formal, science-based, risk management strategy that permits implementation of actions despite uncertainties (USACE, 2019r). Knowledge gained from monitoring and evaluating results will be used to adjust and direct future decisions. Simply stated, AM is learning while doing in the face of uncertain outcomes. These AM concepts are consistent with those presented in the U.S. Department of Interior's AM technical guide (Williams et al., 2009). Figure 5.4-2 illustrates the steps in an AM cycle compatible with USACE projects.

[63] Governance is the framework for how USACE will continue to work with the WATER forum to implement the preferred alternative. It describes the entities involved, the various forums set up to advise on different subject matter, and how information from those forums will be considered by USACE in implementing the preferred alternative.

The use of decision criteria plays a key role in the evaluation of management measures and in the adaptive decision-making process. As described in Appendix N, decision criteria include performance metrics, targets, and decision triggers and are defined as follows:

- Performance Metric – A specific metric or quantitative indicator that is monitored and can be used to estimate and report consequences of management alternatives with respect to a particular objective.
- Target – A specific value or range of performance metric that defines success. Targets can be quantitative values or overall trends (directional or trajectory).
- Decision Trigger - A pre-defined commitment (population or habitat metric for a specific objective) that triggers a change in a management action. Decision triggers are addressed in the Evaluate step (Step 4 of the AM process shown in Figure 5.4-2) and specify the metrics and actions that will be taken if monitoring indicates performance metrics are or are not reaching target values. In some cases, a decision trigger may be learning a new piece of information that triggers the Continue/Adjust/Complete step (Step 5 of the AM process shown in Figure 5.4-2).

The process described in the AMP is consistent with the NEPA purpose of informed decision-making and takes the process further in addressing uncertainties and data gaps that may be revealed during implementation of the selected alternative (40 CFR 1500.1(c)). This allows decision makers to adjust based on new information while observing project performance, thereby enabling transition from the planning and designing efforts associated with this WVS PEIS to implementation of the selected management actions using AM. The AMP is a living document that will be updated as new information is learned from monitoring of actual performance of the selected alternative and processed through a governance structure.

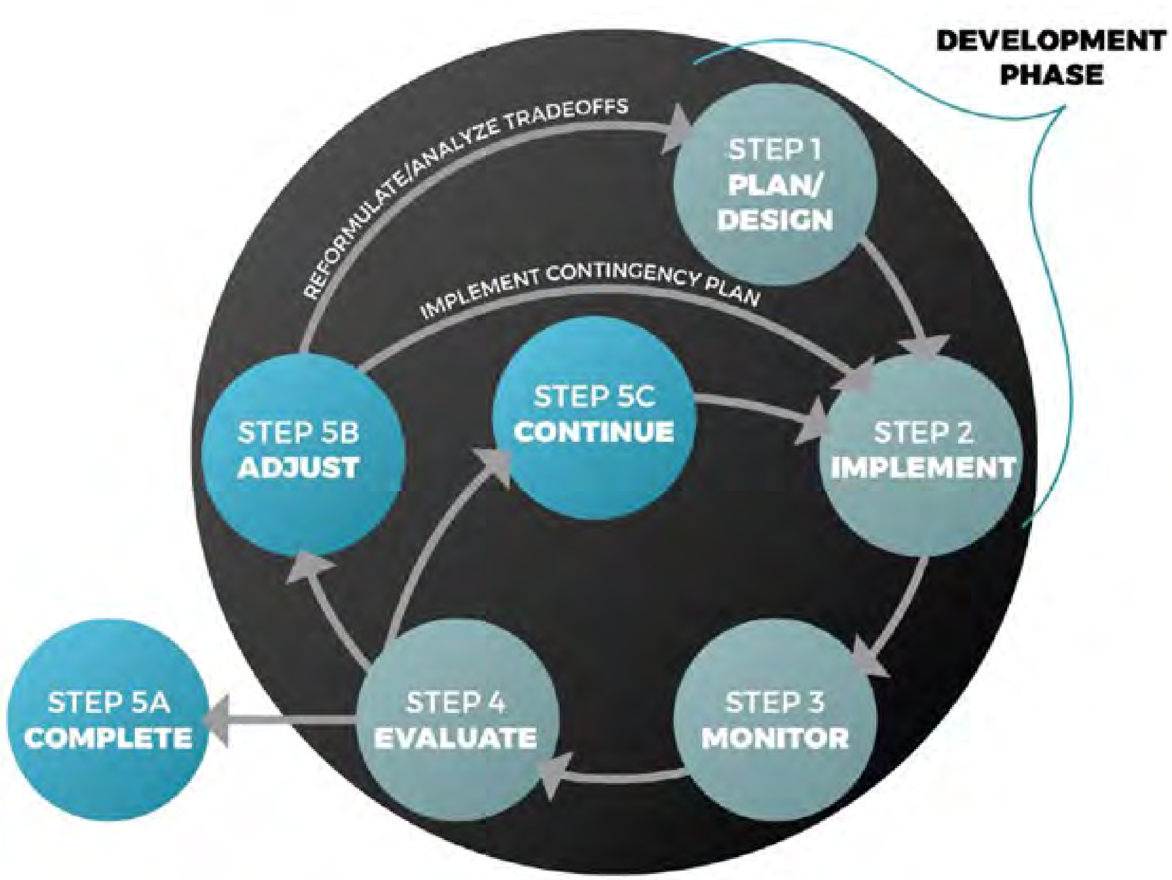


**Figure 5.5-2. USACE Adaptive Management Cycle**

# CHAPTER 6 - PUBLIC INVOLVEMENT

NEPA requires lead agencies to invite public involvement prior to decision-making on proposed actions that may affect the environment. Public involvement often starts with "scoping," which is the process of soliciting input from stakeholders such as tribes, the public (both private citizens and non-governmental organizations or "NGOs"), and other agencies. Scoping gives the lead agency perspectives from various stakeholders and helps to develop aspects of the purpose and need for the proposed action and the development of preliminary alternatives to the proposed action. Scoping also helps identify the key issues for consideration in an EIS.

## 6.1 PUBLIC SCOPING OUTREACH

USACE began public outreach for the project early in the planning process with press releases, a newspaper article in the Eugene, Oregon newspaper the *Register Guard*, and a public-facing project website. Flyers and handouts were posted at USACE properties and distributed at local Willamette Valley events, and stakeholders were notified of project developments via email. USACE also organized a presentation for the North Santiam, McKenzie, Middle Fork, and Coast Fork Watershed Councils and the Association of Oregon Counties.

### 6.1.1 Notification of Public Scoping Meetings

Scoping for the PEIS formally began on April 1, 2019 with the publication of a Notice of Intent (NOI) in the *Federal Register* (Vol. 84, No. 62, pp. 12,237 – 12,238). The NOI described USACE's intent to prepare this PEIS to address the continued O&M of the WVS in accordance with authorized project purposes while meeting ESA obligations to avoid jeopardizing the continued existence of ESA-listed species.

Public comments were accepted until June 28, 2019. The NOI also notified the public of the scoping meetings from June 4 to 13, 2019. In addition to the NOI, the meetings were advertised in 15 newspapers and with press releases, flyers, the project website, email, and social media.

### 6.1.2 Public Scoping Meetings

Five scoping meetings were held at various locations throughout the Willamette Valley to provide an opportunity for interested stakeholders from different communities to attend. In addition to a presentation, an open house format was used to encourage discussion and information sharing and to ensure that the public had opportunities to speak with representatives of USACE.

Informational posters, a public comment brochure, a public scoping meeting handout providing instructions on use of the public comment portal, and a scoping informational brochure were also available at the public scoping meetings. Meeting participants included private citizens; utility board/councils; watershed councils; farm associations; NGOs; city, state, and federal representatives; and elected officials. An average of 16 people attended each scoping meeting.

### 6.1.3 Scoping Comments

A total of 92 correspondence documents were received via email, mail, comment brochures that were distributed and then collected at meetings, and the public comment portal. Many of the correspondence documents contained multiple comments on different topics.

A total of 384 comments were received from private citizens, NGOs, government agencies, and tribes. To ensure that all comments were identified and properly reviewed, the comments were first assigned a comment identification number and documented in a database. The comments were then organized, analyzed, and categorized according to six topics (alternatives, authority, PEIS general, environmental effects, mitigation, not a comment about the PEIS). Table 6.1-1 shows the number of comments received by topic.

**Table 6.1-1. Public Scoping Comments Received by Topic**

| Topic | Number of Comments Received |
|---|---|
| Alternatives | 183 |
| Authority | 10 |
| PEIS General | 86 |
| Environmental Effects | 90 |
| Mitigation | 5 |
| Not a Comment about the PEIS | 10 |
| **Total** | **384** |

The comments were further categorized by sub-topics (e.g., ESA-listed species and/or compliance, FRM, NEPA process, water storage and allocation) to allow USACE to better understand the input received from the public. The comments were used to inform the scope of analysis, alternatives development, and effects to resources in the Draft PEIS.

The Willamette Valley System Operation and Maintenance Programmatic Environmental Impact Statement Public Scoping Report includes more details on the scoping process and comments, a database of comments received, and all scoping materials (Appendix P – Public Scoping Report).

## 6.2 KEY ISSUES AND RESOURCE CONCERNS

The NEPA public scoping process resulted in the identification of issues important to WVS stakeholders. The following list of key issues and resource concerns associated with the proposed alternatives is not all-inclusive.

### 6.2.1 Endangered Species Act

The largest number of comments received for any single issue or resource concern (136 comments of 384 total) involved ESA-listed species and compliance with the ESA, mainly with regard to UWR spring Chinook salmon, UWR steelhead, and bull trout. Concerns were raised about how dams would affect anadromous fish including fish migration patterns, water conditions affecting fish passage and fish populations, and general ecosystem effects.

### 6.2.2 Flood Risk Management

There were 48 comments pertaining to flood risk management. The scoping process identified concerns and suggestions related to retaining or improving the current WVS to assist with flood risk. Concerns in this area related to both preserving economic activities and human resources within the WVS and balancing flood risk mitigation with the need to ensure the availability of appropriate fish and wildlife habitat.

### 6.2.3 NEPA Process

There were 49 comments pertaining to the NEPA Process. Commenters focused on the scope of the PEIS, the review process, and how the PEIS may affect other ongoing USACE NEPA analyses within the WVS. Cumulative effects to natural resources and ecosystems resulting from O&M of the WVS were identified as a concern. Commenters identified elements that should potentially be included in the scope of the PEIS, such as recent research on fish habitats, water allocation and storage, and streamflow as it relates to boating, maintenance of hydropower infrastructure, and water quality.

### 6.2.4 Water Storage and Allocation

There were 48 comments pertaining to water storage and allocation. Comments were received advocating for and against adjustments to water storage capacity and allocation. Commenters suggested that water allocation and storage should be designed to meet increasing irrigation demands. Concerns were voiced about potential adverse effects to the local community should water storage allocation be decreased. Some commenters raised concerns that water storage and allocation changes could negatively affect fish populations and habitat.

### 6.2.5 Water Quality

There were 25 comments pertaining to water quality. Comments were received concerning the potential effect of O&M activities on the transformation or migration of contaminants found within the WVS. Comments called for an assessment of water quality issues and presentation of data associated with likely effects to water quality from proposed alternatives. Some commenters requested water quality sampling to ensure public safety in regard to drinking water. Overall, comments called for consideration of water quality issues, both physical and chemical, within the WVS.

### 6.2.6 Recreation

There were 24 comments pertaining to recreation. Comments were received advocating for recreational opportunities such as through recreational releases for boating and whitewater paddling as well as for sailing. Commenters also identified concerns with the recreational effects of algal blooms and pointed out that any proposed changes to reservoir levels could affect recreational use of the WVS and jobs associated with those recreational opportunities. The comments included discussion of the local and regional economies tied to recreational opportunities in the WVS. Commenters also suggested USACE consider and evaluate the recreational effects of fishing on ESA-listed species.

## 6.3 INTERAGENCY COORDINATION

Following scoping, USACE held monthly meetings with the Cooperating Agencies to provide regular updates to the PEIS status and to solicit feedback. Additionally, in April of 2020, USACE held workshop meetings with Cooperating Agencies to present information about the project and to solicit their feedback (see Appendix L for a description of Cooperating Agencies). These meetings are summarized below:

- On April 9, 2020, a webinar was held with USACE, Confederated Tribes of Grand Ronde Community of Oregon, NMFS, BoR, BPA, EPA, ODFW, ODEQ, and ODA to discuss the results of developing BiOp measures into preliminary alternatives.
- On April 15, 2020, a webinar was held with USACE, Confederated Tribes of Grand Ronde Community of Oregon, NMFS, BoR, BPA, EPA, ODFW, ODEQ, ODA, and OWRD in which USACE presented the background of the project, purpose and need, review of the alternatives' development process, and a status and overview of the preliminary alternatives.
- On April 24, 2020, a webinar was held with USACE, Confederated Tribes of Grand Ronde Community of Oregon, NMFS, BoR, BPA, EPA, ODFW, ODEQ, ODA, and OWRD in which USACE provided information regarding the NAA.

## 6.4 TRIBAL CONSULTATION

Executive Order 13175, Consultation and Coordination with Indian Tribal Governments, calls for regular and meaningful consultation and collaboration with tribal officials in the development of federal policies that have tribal implications and for strengthening government-to-government relationships between the United States and tribal governments. USACE committed from the outset to consult with federally recognized tribes throughout the PEIS development process.

Tribal consultation for this project began in 2018. USACE sent project initiation letters to Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians, Cow Creek Band of Umpqua Indians, the Confederated Tribes of Grand Ronde Community of Oregon, the Confederated Tribes of Siletz Indians, and the Confederated Tribes of Warm Springs.

On January 18, 2021, USACE mailed a letter to invite to the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians, Cow Creek Band of Umpqua Indians, Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Siletz Indians, and Confederated Tribes of Warm Springs to be Cooperating Agencies. The Confederated Tribes of Grand Ronde

Community of Oregon accepted and signed a Memorandum of Understanding with USACE dated February 28, 2020, which can be found in Appendix O -Tribal Coordination & Perspectives. The tribe has been active in cooperator meetings.

The Confederated Tribes of Siletz Indians expressed interest in person and by email but did not sign a Memorandum of Understanding. The tribe has participated in cooperator meetings. USACE sent a letter dated September 13, 2019, reinviting the Confederated Tribes of Warm Springs to be a Cooperating Agency. This was based on further phone calls and in person meetings with the Confederated Tribes of Warm Springs personnel. The Confederated Tribes of Warm Springs staff have attended some cooperator meetings, but a Memorandum of Understanding between USACE and the Confederated Tribes of Warm Springs has not been signed.

Two tribal entities, the Columbia River Inter-Tribal Fish Commission and the Confederated Tribes of Grand Ronde Community of Oregon, responded to 2019 PEIS scoping outreach. These comments can be found in Appendix P- Public Scoping, and the key issues are summarized in Section 6.2.

USACE sent a letter dated September 30, 2021, inquiring on the tribes' interest to engage in PEIS development. The letter was sent to the Coquille Indian Tribe, Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians, Cow Creek Band of Umpqua Indians, Confederated Tribes of Siletz Indians, Confederated Tribes of Warm Springs, Klamath Tribes, Nez Perce Tribe, Confederated Tribes of the Umatilla Indian Reservation, and the Yakama Nation of Indians. The letter was not sent to the Confederated Tribes of Grand Ronde Community of Oregon as they were an active Cooperating Agency. The Cow Creek Band of Umpqua Indians and Nez Perce Tribe did not respond. The Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians, Coquille Indian Tribe, and Klamath Tribes deferred to other tribes and requested to not be consulted further. The Confederated Tribes of the Umatilla Indian Reservation and the Yakama Nation of Indians provided points of contact and requested further engagement.

USACE requested PEIS input by email correspondence on June 6, 2022 to the Confederated Tribes of the Umatilla Indian Reservation, Yakama Nation of Indians, Confederated Tribes of Grand Ronde Community of Oregon, Confederated Tribes of Siletz Indians, Confederated Tribes of Warm Springs, the Nez Perce Tribe, and Cow Creek Band of Umpqua Indians.

## 6.5 ADDITIONAL PUBLIC OUTREACH

In 2021, USACE released a publicly accessible Virtual Room, an interactive website organized like a three-dimensional public meeting room with clickable "boards" that provided information summarizing the status of the PEIS. The information provided included an overview of the WVS PEIS background and process, including the alternatives formulation process. The Virtual Room also included an interactive map that provided descriptions of actions proposed under each alternative and allowed the visitor to explore where actions were proposed under each alternative.

Following release of the Virtual Room, USACE held an informational public meeting during which USACE subject matter experts presented the alternatives and the alternatives formulation process current at the time The presentation also provided an overview of each alternative, including the actions that make up the alternative and their proposed locations.

Over 25 members of the public attended the virtual meeting. USACE fielded questions from attendees during the meeting, but no formal comments were recorded as this was intended only as an informational meeting to update the public on the status of the PEIS.

## 6.6 DRAFT PEIS PUBLIC OUTREACH

As of November 25, 2022, the Draft PEIS is being issued for a 55-day public review period. The Draft PEIS is available for review on the Portland District's website. USACE is requesting review comments from tribes and federal and state agencies, as well as various interested parties, and the public.

In anticipation of the release of the Draft PEIS for public review, USACE plans to hold several public meetings to provide an overview of the PEIS and to inform participants on how they can access the draft PEIS for their review and how they can provide their comments.

USACE will consider all received correspondence and comments. The Corps has sent out the Public Notice of Availability for the release of the Draft PEIS for public review to tribes, interested persons, agencies, and groups.

# CHAPTER 7 - COMPLIANCE WITH ENVIRONMENTAL LAWS, REGULATIONS, AND EXECUTIVE AND SECRETARIAL ORDERS

Chapter 7 considers compliance of the Willamette Valley System (WVS) operation and maintenance (O&M) Programmatic Environmental Impact Statement (PEIS) within the context of the complex suite of federal environmental statutes, regulations, and Executive and Secretarial Orders that collectively govern the U.S. Army Corps of Engineers' (USACE's) planning activities and O&M of the WVS.

## 7.1 ENVIRONMENTAL OPERATING PRINCIPLES

The USACE) has reaffirmed its commitment to the environment by formalizing a set of "Environmental Operating Principles" applicable to all of its decision-making programs. These principles foster unity of purpose on environmental issues, reflect a new tone and direction for dialog on environmental matters, and ensure that employees consider conservation, environmental preservation, and restoration in all USACE activities. The principles are described in Engineer Circular 1105-2-404 "Planning Civil Work Projects under the Environmental Operating Principles," 1 May 2003.

This WVS Programmatic Environmental Impact Statement (PEIS) addresses USACE Environmental Operating Principles as described below.:

1. Foster sustainability as a way of life throughout the organization.

Environmental sustainability, when applied to a water resource project, must be designed to balance three major elements: environmental health, economic prosperity, and social well-being.

Several objectives of the Proposed Action are intended to support environmental health. They include:

- Increase anadromous Endangered Species Act (ESA)-listed fish passage survival at WVS dams.
- Improve water management during the conservation season to benefit anadromous ESA-listed fish and other authorized project purposes.
- Reduce pollutant levels to restore impaired water quality associated with the WVS dams to benefit anadromous ESA-listed species.
- Reduce spawning and rearing habitat competition caused by hatchery fish.

The preferred alternative will also contribute to future economic prosperity by creating jobs during construction and social well-being by continuing to reduce flood risks for the community.

2. Proactively consider environmental consequences of all USACE activities and act accordingly.

USACE has proactively considered environmental consequences of the Proposed Action. Potential consequences to environmental resources have been analyzed for the alternatives. Measures to avoid and reduce impacts on resources have been developed and will be implemented. For example, the PEIS considers the implications of the Proposed Action (and all other alternatives) for existing reservoir recreational uses and hydroelectricity generation.

3. Create mutually supporting economically and environmentally sustainable solutions.

The project will provide national and regional economic development benefits. Construction of the project is anticipated to support additional jobs and provide income for workers.

The proposed project reduces risk of flooding while balancing environmental impacts against levels of residual risk.

4. Continue meeting USACE's corporate responsibility objectives and maintain accountability under the law when carrying out actions that may impact human and natural environments.

The values of environmental sustainability are incorporated into the Nation's laws and mandates to governmental and private actors. The statute that provides a basis for evaluation of environmental impacts is the National Environmental Policy Act (NEPA). The applicable Principles, Requirements and Guidelines (PR&G) found in the Principles, Requirements and Guidelines for Water and Land Related Resources Implementation Studies (2014) provides a guide for seeking sustainable solutions in Civil Works projects.

The Proposed Action incorporates a coordinated approach to meet the purpose and need of the plan while complying with environmental laws such as NEPA, the Clean Water Act, the Clean Air Act, the Fish and Wildlife Coordination Act, and the Endangered Species Act, among others. All applicable requirements will be met.

5. Consider the environment in employing a risk management and systems approach throughout life cycles of projects and programs.

The environment was considered in employing a risk management and systems approach. USACE will continue to communicate impacts and residual risk to stakeholders and the public throughout the life cycle of the proposed project.

6. Leverage scientific, economic, and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner.

USACE must effectively utilize sources of expertise among other professional organizations, and other Federal, state, and local entities to address problems of regional and national significance. USACE has utilized the scientific expertise within the agency and the expertise of federal and state resource agencies. USACE also engaged tribes, NGOs, multiple levels of government, and the public, each of whom brings specialized knowledge and perspectives to the table.

7. Employ an open, transparent process that respects views of individuals and groups interested in USACE activities.

USACE has sought the views of individuals and groups on the WVS PEIS via the EIS scoping process and other mechanisms. USACE will continue to provide information to keep the public informed on the WVS PEIS. USACE will continue to actively listen and respond to and incorporate public concerns.

## 7.2 TRIBAL TREATIES AND TRUST RESPONSABILTIES

Since time immemorial, Native American tribes have inhabited the Willamette River Basin (WRB). These tribes successfully subsisted on the abundant natural resources of the area and built thriving communities that relied on the lands to sustain their way of life. Through treaties, executive orders, judicial decisions, and legislation, tribes ceded most of their aboriginal territory to the United States. Tribes retained smaller portions of land for their reservations on the outer edges or outside of the Willamette Valley. Many tribes, through treaties, retained the right to hunt, fish, and gather in their usual and accustomed locations, including areas outside of their reservations.

USACE has a unique legal and political relationship with tribal governments as sovereigns. This Federal trust responsibility is established through, and confirmed by, the U.S. Constitution, treaties, statutes, executive orders, and judicial decisions. Table 7.2-1 lists the federally recognized tribes affected by the proposed action and the Willamette River Basin relevant treaties.

**Table 7.2-1. Affected Indian Tribes and WRB-Relevant Treaties**

| Federally-Recognized Tribes | Treaties |
|---|---|
| Confederated Tribes of Grand Ronde Community of Oregon | Rogue River Treaty, September 10, 1853<br><br>Treaty with Cow Creek Band of Umpqua, September 19, 1853<br><br>Rogue River Treaty, November 15, 1854<br><br>Treaty with the Chasta, Scoton, and Umpqua, November 18, 1854<br><br>Treaty with the Umpqua and Kalapuya, November 29, 1854<br><br>Willamette Valley Treaty, January 22, 1855<br><br>Treaty with the Molalla, December 21, 1855 |

| Federally-Recognized Tribes | Treaties |
|---|---|
| Cow Creek Band of Umpqua Tribe of Indians | Cow Creek Band of Umpqua Treaty, September 19, 1853 |
| Confederated Tribes and Bands of the Yakama Nation | Yakama Treaty, June 9, 1855 |
| Nez Perce Tribe | Nez Perce Treaty, June 11, 1855 |
| Confederated Tribes of the Umatilla Indian Reservation | Walla Walla Treaty, June 9, 1855 |
| Confederated Tribes of Warm Springs | Treaty of 1855 (also Treaty with the Tribes of Middle Oregon, June 25, 1855) |
| Confederated Tribes of Siletz Indians | Rogue River Treaty, September 10, 1853 |

### 7.2.1 Executive Order 13175, Consultation and Coordination with Indian Tribal Governments

This order directs federal agencies to formulate and establish "regular and meaningful consultation and collaboration with tribal officials in the development of federal policies that have tribal implications, to strengthen the United States government-to-government relationships with Indian tribes, and to reduce the imposition of unfunded mandates upon Indian tribes." This consultation is meant to work toward a mutual consensus and is intended to begin at the earliest planning stages, before decisions are made and actions are taken. Consistent with this executive order, USACE initiated tribal consultation for this project in 2018. Section 6.4 describes tribal consultation efforts in detail. Additionally, each tribe was informed of the opportunity to request government-to-government consultation with USACE leadership anytime they believed it was necessary.

### 7.2.2 Secretarial Order 3175, U.S. Department of The Interior Responsibilities For Indian Trust Assets

Secretarial Order 3175 requires U.S. Department of the Interior bureaus and offices to consult with the recognized tribal government with jurisdiction over the trust property that a proposal may affect and ensure that any anticipated effects are explicitly addressed in planning, decision, and operational documents including EISs. In compliance with Secretarial Order 3175, this EIS has analyzed potential effects to Indian Trust Assets in Sections 3.24 and 4.24.

## 7.3 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) OF 1969 (42 UNITED STATES CODE [U.S.C.] §§ 4321–4347)

NEPA was established to ensure that the federal government appropriately considers the potential effects on the human environment of major federal actions. prior to implementing those actions. USACE is proposing updates to its operation and maintenance (O&M) of the WVS and has prepared this PEIS in accordance with the NEPA, the Council on Environmental

Quality's [CEQ] NEPA-implementing regulations (40 Code of Federal Regulations [CFR] Part 1500-1508), and the USACE NEPA-implementing regulations (33 CFR Part 230)[64].

### 7.2.3 Programmatic NEPA Review

The NEPA compliance process can be conducted for a specific project or for an entire program. As established in Section 1.1, a programmatic approach makes the most sense for operation and maintenance of the WVS, which consists of multiple projects, components, and activities within a shared geography (Oregon's Willamette River Basin) that are managed individually and in concert to achieve the authorized purposes of the projects and to lessen impacts on ESA-listed species. In accordance with 40 CFR Part 1500-1508 as amended and "Final Guidance for Effective Use of Programmatic NEPA Review" (CEQ 2014), USACE has prepared this PEIS for the WVS to disclose broad effects within the WVS consistent with 40 CFR 1502.4(b) and provide the framework for future decisions associated with the WVS.

These broad effects of the Proposed Action serve as a starting point for further site-specific evaluation of direct, indirect, and cumulative effects – effectively laying the groundwork for subsequent tiered analyses. Tiering means taking general, preliminary analyses from a programmatic document and adding to it in a subsequent EA or EIS when more detail and specifics about the project are known.

As directed in "Final Guidance for Effective Use of Programmatic NEPA Review" (CEQ 2014), this PEIS presents the agency's anticipated timing and sequence of actions covered under the programmatic document and actions that would be deferred to a later time; and discloses the timeframe or triggers of tiered NEPA review (CEQ 2014). The sequence of future action implementation and associated tentative NEPA review paths are further discussed in Appendix N1 – Implementation Plan. Subsequent actions triggered in accordance with the adaptive management, monitoring, and mitigation protocols may also require further NEPA review. These potential actions are discussed in Appendix N2 – Adaptive Management Plan and Appendix N3 – Monitoring and Mitigation.

### 7.2.4 Evaluation to Tier to the WVS PEIS

The WVS PEIS allows for the tiering of subsequent site-specific actions or measures, as needed. Any subsequent tiered documents will need to review briefly what level of analysis has been considered in the PEIS and whether it is still contemporary.

The PEIS fully assesses the effects of most operational measures that do not require detailed design and construction to implement immediately. This PEIS has analyzed the measures fully, and further NEPA evaluation will not be necessary. These measures are discussed further below in 7.2.2.1.

[64] The PEIS complies with the 1978 CEQ NEPA implementing regulations as amended.

Some operational measures may eventually require dam modifications to address operational and dam safety concerns; and may need further analysis. If USACE determines that this PEIS has not sufficiently evaluated the potential environmental effects of an action, then tiered NEPA analysis will be required. Dam safety modifications would likely only evaluate resource topics that are relevant to dam safety modification alternatives considered at the site-specific level, and may not include analysis of the same resource topics discussed in this PEIS. Operational measures are discussed further below in 7.2.2.2.

For measures that would require site-specific construction, USACE would perform a subsequent NEPA phase tiered to this PEIS. During this subsequent NEPA phase, the effects analysis would be informed by the site-specific designs performed at that time for measures requiring construction. Subsequent analysis would include appurtenant or ancillary implementation features or activities, such as use of construction equipment, site preparation, access, staging, and material storage and transfer facilities. Typical descriptions of several activities that may potentially occur during implementation of the measures are summarized in Section 3.1.1.2 and further described in Appendix A. These measures are discussed further in below in 7.2.2.3.

#### *7.2.2.1 Operational measures with no further NEPA analysis required*

The operational measures included in the Proposed Action listed by project location in Table 3.1-2 do not require further analysis and are considered fully evaluated through the programmatic analysis of the WVS PEIS.

**Table 3-1. Operational measures in the Proposed Action with no further site- or project-specific NEPA analysis required**

| Measures | Locations[1] |
|---|---|
| **Flow Measures** | – |
| 30b. Refined Integrated temperature and habitat flow regime | FRN, CTG, DOR, DEX, LOP, FCR, HCR, CGR, BLU, FOS, GPR, BCL, DET |
| 304. Augment instream flows by using the power pool | LOP, HCR, GPR, DET |
| 718. Augment instream flows by using inactive pool | FCR, BLU |
| **Water Quality Measures** | – |
| 166. Use Regulating Outlets for Temperature Management | GPR |
| 721. Use spillway for surface spill in summer | GPR |
| **Downstream Passage Measures** | – |
| 40. Deeper fall reservoir drawdowns for downstream fish passage | GPR |
| 714. Pass water over spillway in spring for downstream fish passage | GPR |

| Measures | Locations[1] |
|---|---|
| **Measures Common to All Alternatives** | – |
| 719. Adapt Hatchery Program | North Santiam, South Santiam, McKenzie, and Middle Fork Willamette sub-basins |
| Fall Creek Drawdown | FCR |
| Continued Operation of Existing Adult Fish Facilities | North Santiam, South Santiam, South Fork McKenzie, and Middle Fork Willamette sub-basins |
| Scheduled/Routine Maintenance of WVS Facilities | Basin-wide |
| Near-Term Operations | LOP, HCR, FCR, CGR, FOS, GPR, DET |

[1]Dam Abbreviations: BCL – Big Cliff; BLU – Blue River; CGR – Cougar; CTG – Cottage Grove ; DET – Detroit; DEX – Dexter; DOR – Dorena; FCR – Fall Creek; FOS – Foster; FRN – Fern Ridge; GPR – Green Peter; HCR – Hills Creek; LOP – Lookout Point

#### *7.2.2.2 Operational measures with limited subsequent tiered NEPA analysis*

Operational measures listed in Table 3-2 by project location would eventually require dam modifications (i.e., structural changes) to address operational and dam safety concerns. In these cases, the effects analysis would be limited to the construction activities needed to address operational and dam safety concerns. Effects for some resources (e.g., visual resources) may be fully evaluated under this PEIS; the subsequent tiered analysis would not include any additional analysis for these resources. Prior to implementation, USACE would determine whether each resource discussed in Chapters 3 and 4 has been adequately addressed at the programmatic level or whether additional analysis would be necessary during a subsequent tiered analysis. Tiered analyses for relevant resources will summarize the issues already discussed in the WVS PEIS; incorporate discussion from the WVS PEIS by reference; and concentrate on the effects that would be specific to the site or project.

**Table 3-2. Operational measures in the Proposed Action that would require site- or project-specific NEPA analysis**

| Measures | Locations |
|---|---|
| **Downstream Passage Measures** | – |
| 40. Deeper fall reservoir drawdowns for downstream fish passage for the drawdown operation to the DT | CGR |
| 720. Spring reservoir drawdown for downstream fish passage for the drawdown operation to the DT | CGR |
| **Measures Common to All Alternatives** | – |

| Measures | Locations |
|---|---|
| 726. Maintenance of existing and new fish release sites above dams | North Santiam, South Santiam, South Fork McKenzie, and Middle Fork Willamette sub-basins |
| Major Maintenance and Rehabilitation of WVS Facilities | Basin-wide |

#### *7.2.2.3 Structural measures with subsequent tiered NEPA analysis*

The structural measures listed in Table 3-3 by project location would be evaluated during subsequent tiered analyses. There are limitations in available information and uncertainty regarding the timing and location for these measures; as such, this PEIS provides the initial, general effects analysis of these structural measures. The subsequent effects analysis would be informed by the site-specific designs performed at that time for measures requiring construction. Subsequent analysis would include appurtenant or ancillary implementation features or activities, such as use of construction equipment, site preparation, access, staging, and material storage and transfer facilities.

**Table 3-3. Structural measures in the Proposed Action that would require site- or project-specific NEPA analysis**

| Measures | Locations |
|---|---|
| **Water Quality Measures** | – |
| 105. Construct water temperature control tower | DET |
| 479. Foster Fish Ladder Temperature Improvement | FOS |
| **Downstream Passage Measures** | – |
| 392. Construct structural downstream fish passage | LOP, FOS, DET |
| **Upstream Passage Measures** | – |
| 52. Provide Pacific lamprey passage and infrastructure | GPR |
| 722. Construct adult fish facility | GPR |
| **Measures Common to All Alternatives** | – |
| 384. Gravel Augmentation | North Santiam, South Santiam, and McKenzie River Basins below Big Cliff, Foster, Cougar, and Blue River dams |
| 9. Maintain revetments using nature-based engineering or alter revetments for aquatic ecosystem restoration | Basin-wide |

### 7.2.5 Evaluation of new information that could require a supplemental analysis

A supplemental analysis is required when there is significant new information relevant to the Proposed Action or its impacts (CEQ 2014). Introduction of a new and viable alternative, fundamental changes to existing plans (including connected actions), or a change in purpose and scope could necessitate a supplemental analysis. In addition, if new information prompts the need to analyze effects to a new resource that has not been analyzed in the PEIS; a supplemental analysis could also be required.

Alternatively, if a new tiered NEPA analysis can include consideration of the programmatic issues, then the tiered analysis can also serve as the vehicle for supplementing the PEA or PEIS. When the new information's effects are limited to potential impacts or alternatives associated with the project- or site-specific decision, then the tiered analysis can address the new information without having to supplement the PEIS (CEQ 2014).

Programmatic NEPA reviews allow two options to complete supplementation. One option is to supplement the original PEIS, and another option is to tier NEPA evaluation of programmatic actions. The determination to evaluate new information during a tiered NEPA review relies on whether the effects of new information are limited to sequential phases of activities, or project- or site-specific activities (CEQ 2014). Following completion of the WVS PEIS, USACE would evaluate new information and determine how to analyze its effects. If supplementation is required, then the Corps would determine whether to accomplish supplementation through preparation of a tiered NEPA document or a supplemental NEPA document.

### 7.2.6 Agency and public involvement during the programmatic or subsequent tiered review

In the sections above, USACE has prepared a list of measures where effects are addressed at the programmatic level of NEPA analysis and where effects would be further analyzed during subsequent tiered NEPA analysis. This information is intended to clarify to interested parties when to provide comment; that is, whether to raise issues during the programmatic analysis, or to raise them in any subsequent tiered analyses. Participation during the broad NEPA programmatic review will ensure that stakeholder concerns are raised early on the broad effects instead of at the subsequent tiered level where site- or project- specific effects would be the focus of review and involvement. Additional information on the public involvement process for the WVS PEIS is provided in Chapter 6.

## 7.4 ENDANGERED SPECIES ACT, AS AMENDED (16 U.S.C. §§ 1531–1544)

In order to comply with obligations under CFR 50 CFR 402.16, the USACE and NMFS reinitiated consultation of the 2008 NMFS Biological Opinion to address changes to the action due to lack of available funding for key Reasonable and Prudent Alternative (RPA) elements. USACE notified NMFS of that decision on behalf of the Action Agencies in a letter dated April 9, 2018. Though USACE and USFWS have yet to formally re-initiate consultation the current USFWS biological opinion is set to expire in 2024. Since the USFWS determination of non-jeopardy was based on the completion of the NMFS 2008 RPA actions, the USFWS consultation will also need to be reconsulted on. Formal consultation on the revised proposed action, which is also the preferred alternative of this PEIS, is scheduled to begin late in 2022, with final the biological opinions to be issued by NMFS and USFWS in late 2023. Prior to the initiation of formal consultation there have been extensive pre-consultation coordination on both the PEIS and proposed action to date, which is ongoing.

## 7.5 FISH AND WILDLIFE COORDINATION ACT (FWCA) (16 U.S.C. §661 ET SEQ.)

USACE formally requested coordination under the FWCA (16 U.S.C. 661-667e as amended) with USFWS and NMFS in letters dated August 10th, 2021. The USACE and USFWS entered into an agreement for FWCA coordination in an intragovernmental reimbursable activity agreement dated September 1, 2021. Development of the USFWS scope of analysis was a collaborative effort between the NMFS, USFWS, and USACE, including the fish and wildlife resources to be analyzed (see Table 7.5-1 below). As part of the deliverables under this scope USFWS has submitted a draft Fish and Wildlife Conservation Act Report (CAR) on the 24th of May 2022.

**Table 7.5-1 Fish and wildlife resources evaluated under the draft CAR for USFWS.**

| Habitat Types | Evaluation Species |
|---|---|
| Upland | Monarch Butterfly (*Danaus plexippus*)<br>Wayside Aster (*Eucephalus vialis*)<br>Black Cottonwood[a]<br>Bradshaw's Lomatium[b] |
| Prairie | Dusky Canada Goose (*Branta canadensis occidentalis*)<br>Thin-leaved Peavine (*Lathyrus holochlorus*)<br>Bradshaw's Lomatium[b] |
| Wetland/ Off-Channel | Northern Red-Legged Frog (*Rana aurora*)<br>Pacific Lamprey (*Entosphenus tridentatus*)<br>American Beaver[a]<br>Black Cottonwood[a]<br>Oregon Chub[b] |
| Riparian | Foothill Yellow-Legged Frog (*Rana boylii*)<br>Western Pond Turtle (*Actinemys marmorata*)<br>American Beaver[a]<br>Black Cottonwood[a] |
| Riverine | Coastal Cutthroat Trout (*Oncorhynchus clarki clarki*)<br>Western Ridged Mussel (*Gonidea angulata*)<br>American Beaver[a]<br>Oregon Chub[b] |

[A] Keystone Species

[B] Delisted Species

As part of its efforts USFWS coordinated closely with resource experts from the State of Oregon Department of Fish and Wildlife, detailed in an email to USACE staff on November 17th, 2021. The USFWS has provided a suite of conservation measures based on species and habitat types which is currently being evaluated by the USACE. A final CAR will be issued and integrated into the FEIS in the summer of 2023.

A draft CAR from NMFS will not be issued at the time of publication of the Draft EIS. A Draft CAR is anticipated to be issued by NMFS in January 2023. A final CAR from NMFS will be issued in the FEIS and integrated into the FEIS at the time of its publication.

## 7.6 NATIONAL HISTORIC PRESERVATION ACT (54 U.S.C. 300101 ET SEQ.)

The National Historic Preservation Act of 1966, as amended, requires that federal agencies evaluate the effects of federal undertakings[1] on historical, archeological, and cultural resources. The Act also requires the Advisory Council on Historic Preservation have the opportunity to comment on the proposed undertaking. USACE, in coordination with the Oregon State Historic Preservation Office (SHPO) and Native American tribes, is identifying cultural resources and sites in the analysis area for inclusion on the National Register.

USACE has consulted with the State of Oregon under Section 106 of the National Historic Preservation Act and executed a Programmatic Agreement with the SHPO. Currently, USACE is in consultation with the Grand Ronde, Warm Springs, and Siletz Tribes.

## 7.7 EXECUTIVE ORDER 11988, FLOODPLAIN MANAGEMENT, AND EXECUTIVE ORDER 13960, ESTABLISHING A FEDERAL FLOOD RISK MANAGEMENT STANDARD AND A PROCESS FOR FURTHER SOLICITING AND CONSIDERING STAKEHOLDER INPUT

Executive Order (EO) 11988, Floodplain Management, signed 24 May 1977 requires Federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of natural flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "*each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities*."

To comply with EO 11988, projects are formulated and recommended that, to the extent possible, avoid, minimize, and/or mitigate adverse effects associated with use of the floodplain, and avoid inducing incompatible development in the floodplain unless there is no practicable alternative. Under the Order, USACE is required to provide leadership and take action to:

- Avoid development in the base floodplain unless it is the only practicable alternative;
- ➢ Reduce the hazard and risk associated with floods;

[1] "Federal undertakings" have not been specifically identified as synonymous with "major federal actions" under the NHPA or NEPA. However, it is common practice to consider major federal actions to trigger NHPA review and consultations.

- Minimize the impact of floods on human safety, health and welfare; and
- Restore and preserve the natural and beneficial values of the base floodplain.

The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, 10 Feb 1978 (43 FR 6030), as referenced in the Engineering Regulation (ER) 1165-2-26, 30 Mar 1984, require an eight-step process that agencies should carry out as part of their decision-making process on projects that have potential impacts to or within the base floodplain. The eight steps reflect the decision-making process required in Section 2(a) of the Order.

Executive Order 13960, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input, dated January 30, 2015, establishes the Federal Flood Risk Management Standard (Standard), a flexible framework to increase resilience against flooding and help preserve the natural values of floodplains, and sets forth a process for further solicitation and consideration of stakeholder input prior to implementation.

The evaluation and decision making process described below are consistent with the EOs and associated federal policies.

1. Determine if the Proposed Action would be in the base (1 percent [Annual Chance Exceedance] ACE or 1/100-year) floodplain.

Measures of the Proposed Action would be located within the base floodplain; however, implementation of the Proposed Action would avoid, to the extent practicable, long- and short-term adverse impacts to the floodplain. Site-specific designs will be developed prior to construction to ensure that with EOs 11988 and 13960 through technical analysis and coordination with local floodplain management authorities during future site-specific NEPA evaluations described structural in Section 7.2.

2. If the Proposed Action would be in the base floodplain, identify and evaluate practicable alternatives to the action or to locating the action in the base floodplain.

There are no practicable alternatives to locating measures of the Preferred Alternative outside of the base floodplain. However, the purpose and need of the WVS EIS requires that alternatives not alter flood risk.

3. If the action must be in the floodplain, advise the general public in the affected area and obtain their views and comments.

Interested parties may provide comment on floodplain concerns in the affected area through the public comment process of the DPEIS.

4. Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial floodplain values. Where actions proposed to be located outside the base

floodplain will affect the base floodplain, impacts resulting from these actions should also be identified.

No beneficial or adverse effects would occur to floodplain values from actions in the base floodplain. No increase in flood risk is expected due to future operations. Implementation of the Proposed Action will avoid, to the extent possible, long- and short-term adverse impacts to the floodplain. It will also avoid direct and indirect support of development or growth (construction of structure/or facilities, habitable or otherwise) in the base floodplain. Site-specific designs will be developed to ensure that the project complies with EOs 11988 and 13690 through technical analysis and coordination with local floodplain management authorities.

5. If the action is likely to induce development in the base floodplain, determine if a practicable non-floodplain alternative for the development exists.

The action is not likely to induce further development in the base floodplain.

6. As part of the planning process under the P&G, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial floodplain values. This should include reevaluation of the “no action” alternative.

Viable methods to minimize impacts of the array of alternatives were integrated as part of the purpose and need of the Proposed Action through requiring that all alternatives not alter flood risk.

7. If the final determination is made that no practicable alternative exists to locating the action in the floodplain, advise the general public in the affected area of the findings.

Interested parties are advised of that no practicable alternative exists to locating the action in the floodplain through the Notice of Availability of the DPEIS.

8. Recommend the Proposed Action most consistent with the requirements of the Executive Order 11988.

All of the alternatives, including the no action alternative, would have negligible effects to floodplain values. Thus, there is no specific alternative that is of greater consistency with EOs 11988 and 13690.

## 7.8 STATUS OF COMPLIANCE WITH OTHER ENVIRONMENTAL LAWS, REGULATIONS, AND EXECUTIVE ORDERS

In accordance with 40 CFR 1502.25 and 33 CFR 230.25(a), reviews and consultation requirements, analyses, and status of coordination associated with applicable laws, executive orders and memoranda will be summarized in the Draft PEIS.

Table 7.8-1 provides a summary of applicable reviews and consultation requirements, analyses, and status of coordination associated with applicable environmental and cultural resources laws, executive orders, and memoranda. Results of the coordination completed or underway pursuant to these authorities will be summarized in the final WVS PEIS.

**Table 7.8-1 Compliance with Applicable Environmental and Cultural Resources Regulations**

| Relevant Law/Regulation | Requirements | Associated Agencies or Tribes | Compliance Status | Timeframe of Compliance |
|---|---|---|---|---|
| American Indian Religious Freedom Act of 1978, 42 U.S.C. § 1996 | Requires Federal agencies to ensure that religious rights of Native Americans are accommodated during project planning, construction, and operation. | – | Should USACE be notified of any Tribal concerns regarding access to locations of religious or spiritual importance in the WVS PEIS Area of Analysis, it will consult with Tribal representatives to address these concerns. Compliance determination to be made after completion of WVS PEIS Process, public involvement process, SHPO and Tribal consultations and final construction implementation. | During subsequent site-specific evaluation as required |
| Antiquities Act of 1906, 16 U.S.C. §§ 431-433 | The first Congressional act to protect archaeological resources on Federal lands, it has largely been superseded by the Archaeological Resources Protection Act (ARPA). Some Federal agencies will issue Antiquities Act permits rather than ARPA permits for activities on Federal lands managed by that agency. | – | No lands administered by agencies that issue Antiquities Act permits are known within the WVS PEIS project area. Should such lands be identified in the future, the appropriate agency would address Antiquities Act requirements. | During subsequent site-specific evaluation as required |
| Archaeological Resources Protection Act of 1979 (ARPA), 16 U.S.C. §§ 470aa-470mm | Secures the protection of archaeological resources and sites which are on public lands and Indian lands. | – | No public or Indian lands are known within the WVS PEIS project area. Should such lands be identified in the future the appropriate agency would address ARPA requirements. | During subsequent site-specific evaluation as required |
| Bald and Golden Eagle Protection Act of 1940, 16 U.S.C. § 668 et seq. | Prohibits the take, possession, or disturbance of any bald or golden eagle. | U.S. Fish and Wildlife Service | Coordination with the USFWS throughout the WVS PEIS process will ensure identification of bald and golden eagle nesting sites, and avoidance and minimization of effects to bald and golden eagles during implementation. | During subsequent site-specific evaluation as required |

| Relevant Law/Regulation | Requirements | Associated Agencies or Tribes | Compliance Status | Timeframe of Compliance |
|---|---|---|---|---|
| Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. §§ 9601–9675 | Consistent with ER 1165-2-132, USACE will not participate in clean-up or other response actions related to materials regulated by CERCLA. If an action is present and cannot be avoid a designated CERCLA site, the area must be remediated prior and satisfy the requirements of local regulators. | U.S. Environmental Protection Agency | Evaluation of compliance with CERCLA would occur during site-specific evaluation when on-site alternatives are considered. | During subsequent site-specific evaluation as required |
| Clean Air Act, as amended, 42 U.S.C. § 7401–7671q | Clean Air Act (42 U.S.C. 7401 et seq.) Section 176(c) of the Clean Air Act (CAA) requires that Federal agencies assure compliance with the EPA General Conformity Rule to implement Section 176(c) found at 40 CFR Part 93. Under the General Conformity rule, federal agencies must work with state, tribal and local governments in a nonattainment or maintenance area to ensure that federal actions conform to the air quality plans established in the applicable state or tribal implementation plan. In addition, the rule contains a number of "exempted" or "presumed to conform" activities, which may apply to the Proposed Action(s) under the WVS PEIS. | Oregon Department of Environmental Quality<br><br>U.S. Environmental Protection Agency | When direct emissions or indirect emissions would originate in a nonattainment or maintenance area, USACE will conduct a CAA applicability analysis. If required, a CAA Conformity Determination will be completed during subsequent site-specific evaluation | During subsequent site-specific evaluation as required |
| Clean Water Act, as amended, 33 U.S.C. 1251–1387 § 401 | Requires Federal agencies to comply with state water quality standards.<br>USACE would obtain 401 Water Quality Certification (WQC) associated with the discharge of dredged or fill material from the Oregon Department of Water Quality (ODEQ) in accordance with the requirements Section 401 of the CWA. | Oregon Department of Environmental Quality<br><br>U.S. Environmental Protection Agency | USACE will defer obtaining 401 WQC until subsequent site-specific evaluations occur. Refer to the programmatic NEPA process described in Section 7.2 for additional information on subsequent NEPA reviews and associated compliance with other environmental laws. | During subsequent site-specific evaluations as required |

| Relevant Law/Regulation | Requirements | Associated Agencies or Tribes | Compliance Status | Timeframe of Compliance |
|---|---|---|---|---|
| Clean Water Act, as amended, 33 U.S.C. 1251–1387, § 402 | A Section 402 permit is needed for projects that may discharge stormwater to surface waters. | Oregon Department of Environmental Quality | USACE or its contractor will acquire construction stormwater permits from permitting agencies for construction activities subject to Section 402 of the Act.<br>Refer to the programmatic NEPA process described in Section 7.2 for additional information on subsequent NEPA reviews and associated compliance with other environmental laws. | During subsequent site-specific evaluations as required |
| Clean Water Act, as amended, 33 U.S.C. 1251–1387 § 404 | Pursuant to 33 CFR Parts 335 to 338, USACE authorizes discharges of dredged or fill material for operations and maintenance of authorized Civil Works projects. USACE does not issue itself a Clean Water Act (CWA) permit to authorize USACE discharges of dredged material or fill material into waters of the United States (U.S.) but does apply the 404(b)(1) guidelines and other substantive requirements of the CWA.<br><br>USACE would also obtain Removal-Fill permits from Oregon Department of State Lands (ODSL) in accordance with Section 404(t) of the CWA for discharges of fill into Waters of the U.S. | U.S. Army Corps of Engineers<br><br>U.S. Environmental Protection Agency<br><br>Oregon Department of State Lands | Measures in the Preferred Alternative that may require the discharge of dredged material or fill material into waters of the U.S. have not been designed to a sufficient level to perform a 404(b)(1) analysis. USACE would evaluate additional site-specific discharges of dredged or fill material during subsequent NEPA evaluations as described in Section 7.2.4. USACE would include site-specific draft and final 404(b)(1) evaluations of discharges of dredged or fill material associated with subsequent actions within the draft and final NEPA documents respectively. USACE will also obtain applicable Oregon DSL Removal/Fill Permit(s) during the site-specific evaluation(s) in accordance with requirements of Section 404(t) of the Act.<br>Refer to the programmatic NEPA process described in Section 7.2 for additional information on subsequent NEPA reviews and | During subsequent site-specific evaluation as required |

| Relevant Law/Regulation | Requirements | Associated Agencies or Tribes | Compliance Status | Timeframe of Compliance |
|---|---|---|---|---|
| | | | associated compliance with other environmental laws.<br><br>USACE will prepare Statement of Findings (SOF) and include it as part of the environmental documentation in the final site-specific NEPA document.<br><br>See Sections 3.7, and 4.7 for a discussion of broad direct and indirect effects and cumulative effects to wetlands and waters that would be further evaluated as part of a future 404(b)(1) assessment. | |
| Coastal Zone Management Act, 16 U.S.C. 1451 et seq. | Sections 307c(1) and (2) of the Coastal Zone Management Act require that each Federal agency activity within or outside the coastal zone that affects any land or water use or natural resource of the coastal zone or any Federal development project in the coastal zone of a state shall, to the maximum extent practicable, be consistent with approved state management plans. Civil Works activities of USACE in the coastal zone fall within this classification. | Oregon Department of Land Conservation and Development | The Proposed Action would not occur within the Oregon Coastal Zone, nor would it impact coastal resources. | Not applicable |
| Endangered Species Act as amended (16 U.S.C. §§ 1531–1544) | Requires Federal agencies to protect listed species and consult on the federal action. | National Marine Fisheries Service<br>U.S. Fish and Wildlife Service | ESA consultation is ongoing and will be fulfilled prior to completion of the WVS Final PEIS. USACE anticipates consultations would be formal and would result in a Biological Opinion (BiOp) from each consulting agency. | Prior to completion of final WVS PEIS, and during subsequent site- |

| Relevant Law/Regulation | Requirements | Associated Agencies or Tribes | Compliance Status | Timeframe of Compliance |
|---|---|---|---|---|
| | | | | specific evaluation as required |
| Farmland Protection Policy Act (7 U.S.C. §§ 4201, et seq.) | Avoids or minimizes the unnecessary and irreversible conversion of farmland to nonagricultural uses by Federal projects. | National Resource Conservation Service (NRCS) | USACE will coordinate with NRCS should conversion of farmland to nonagricultural uses occur as a result of construction of structural measure. Coordination would occur during future site-specific evaluation of structural measures. Refer to the programmatic NEPA process described in Section 7.2 for additional information. | During subsequent site-specific evaluation as required |
| Marine Mammal Protection Act (MMPA) of 1972, 16 U.S.C. § 1361 et seq. | Requires U.S. citizens and U.S. -based entities to seek incidental take authorization be obtained for the unintentional "take" of marine mammals incidental to activities including construction projects, scientific research projects, oil and gas development, and military exercises. | National Marine Fisheries Service [for whales, dolphins, and sea lions]<br>U.S. Fish and Wildlife Service [for walrus, manatees, sea otters, and polar bears] | There are no marine mammals within the WVS PEIS and there would be no take of marine mammals as a result of the Proposed Action. | Not applicable |
| Marine Protection, Research, and Sanctuaries Act, 16 U.S.C. § 1431 et seq. and 33 U.S.C. §1401 et seq. (1988) | Ensures that ocean disposal will not unreasonably degrade or endanger human health, welfare, or the marine environment. | U.S. Environmental Protection Agency | The Proposed Action would not involve ocean disposal. | Not applicable |

| Relevant Law/Regulation | Requirements | Associated Agencies or Tribes | Compliance Status | Timeframe of Compliance |
|---|---|---|---|---|
| Migratory Bird Treaty Act (MBTA) (16 U.S.C. §§ 703-712) | Prohibits the take, possession or disturbance of any migratory bird, nests, or eggs without a federal permit. | U.S. Fish and Wildlife Service | Measures within proposed action are not anticipated to require MBTA permits. If upon site assessment it is determined that an MBTA permit is required to take MBTA species, then USACE will obtain MBTA permits during site-specific evaluation as required | During subsequent site-specific evaluations as required |
| National Historic Preservation Act (NHPA) (54 U.S.C. 300101 et seq.): Protection of Historic Properties | Requires Federal agencies to identify and protect cultural and historic resources. | Oregon State Historic Preservation Office<br><br>Federally recognized tribes | USACE is coordinating with Tribal representatives and the SHPOs. USACE will continue this coordination to meet requirements of Section 106 of the NHPA prior to implementing any measures that may affect cultural resources. The compliance process will continue until conclusion of the NHPA consultation process through the execution of a Programmatic Agreement. Subsequent federal undertakings would be coordinated individually during site-specific evaluations as required. | Prior to completion of final WVS PEIS, and during subsequent site-specific evaluation as required |
| Native American Graves Protection and Repatriation Act (NAGPRA) 25 U.S.C. 3001 et seq. | Protects Native American and Native Hawaiian cultural items. | Federally recognized tribes | Should any Federal or tribal trust lands be identified in the future and any Native American remains or associated cultural items are discovered, the appropriate agency or Tribe would address the NAGPRA requirements. | During subsequent site-specific evaluation as required |
| Resource Conservation and Recovery Act of 1976 (RCRA), 42 U.S.C. § 6901-6987 | Gives EPA the authority to control hazardous waste from the "cradle-to-grave." This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the management of non-hazardous solid wastes. The 1986 amendments to RCRA enabled EPA to address | U.S. Environmental Protection Agency | USACE identify potential sources of contamination with the WVS Project areas. USACE will maintain a Spill Prevention, Control, and Countermeasure Plan for their facilities and projects. | Prior to completion of final WVS PEIS, and during subsequent site-specific NEPA evaluations as required |

| Relevant Law/Regulation | Requirements | Associated Agencies or Tribes | Compliance Status | Timeframe of Compliance |
|---|---|---|---|---|
| | environmental problems that could result from USTs storing petroleum and other hazardous substances. | | | |
| Executive Order 11988, Floodplain Management, 24 May 1977 | EO 11988 (May 24, 1977) requires a federal agency, when taking an action, to avoid short- and long-term adverse effects associated with the occupancy and the modification of a floodplain. The agency must avoid direct and indirect support of floodplain development whenever floodplain siting is involved. In addition, the agency must minimize potential harm to or in the floodplain and explain why the action is proposed. Additional floodplain management guidelines for EO 11988 were also provided in 1978 by the Water Resources Council. USACE implementation guidance in Engineering Regulation (ER) 1165-2-26 (March 30, 1984). | U.S. Army Corps of Engineers | See section 8.2 | Prior to completion of final WVS PEIS, and during subsequent site-specific evaluation as required |
| Executive Order 11593, Protection and Enhancement of the Cultural Environment | Requires Federal agencies to preserve, restore, and maintain the historic and cultural environment of the U.S. | | USACE policies ensure that all Proposed Actions are performed only after appropriate inventory, management, and protection of cultural resources has occurred. Compliance determination to be made after NEPA evaluation and Section 106 consultation is complete. | Prior to completion of final WVS PEIS |
| Executive Order 11514, Protection and Enhancement of Environmental Quality | Assigns responsibility to Federal agencies to protect and enhance the quality of the Nation's environment. | U.S. Army Corps of Engineers | The proposal minimizes potential environmental impacts, and includes measures to offset the intensity of impacts as described in the Proposed Action. | Prior to completion of final WVS PEIS |

| Relevant Law/Regulation | Requirements | Associated Agencies or Tribes | Compliance Status | Timeframe of Compliance |
|---|---|---|---|---|
| Executive Order 11990, Protection of Wetlands | Requires Federal agencies to protect wetland habitats. | U.S. Army Corps of Engineers | If wetlands as defined in EO 11990 are identified during site-specific evaluation, USACE will offset unavoidable wetland losses in a manner that results in no net loss of wetlands | During subsequent site-specific evaluations as required |
| Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations | Requires Federal agencies to consider and minimize potential impacts on Environmental Justice (EJ) communities. | U.S. Environmental Protection Agency | Chapter 3.20 documents environmental justice concerns and indicates that there would be no disproportionate impact to low income or minority communities. Detailed analysis of EJ populations is located in Appendix L. | Prior to completion of final WVS PEIS, and during subsequent site-specific evaluation |
| Executive Order 13007, Indian Sacred Sites | Directs Federal agencies to provide access and ceremonial use of sacred sites on Federal lands and avoid affecting their physical integrity. | Federally recognized tribes | USACE and the relevant Federal agency will consult with appropriate Tribes to determine if any sacred sites are located on Federal lands within the WVS. | Prior to completion of final WVS PEIS, and during subsequent site-specific NEPA evaluation as required |
| Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks | Under this Executive Order, Federal agencies shall make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children; and shall ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks. | U.S. Army Corps of Engineers | Preparation of the PEIS includes evaluation of environmental health and safety risks, and measures necessary to protect all people, including children, from those risks. There are no measures that would disproportionately affect children or any other group. | Prior to completion of final WVS PEIS, and during subsequent site-specific NEPA evaluation as required |
| Executive Order 13175, Consultation and | Directs Federal agencies to recognize Indian sovereignty in government-to-government relationships and to consult with Tribes in | Federally recognized tribes within WVS area | USACE is consulting with Tribal representatives to identify and address Tribal concerns in the WVS PEIS study area. | Prior to completion of final WVS PEIS, and during |

| Relevant Law/Regulation | Requirements | Associated Agencies or Tribes | Compliance Status | Timeframe of Compliance |
|---|---|---|---|---|
| Coordination with Indian Tribal Governments | adopting regulatory policies that have Tribal implications. | | | subsequent site-specific NEPA evaluations |
| Executive Order 13751, Safeguarding the Nation from the Impacts of Invasive Species | Requires Federal agencies to take reasonable measures to prevent the spread and introduction of invasive species as a result of their management or construction actions. | U.S. Army Corps of Engineers | Preparation of the WVS PEIS will document environmental conditions and effects and informs the determination of compliance with EO 13751 within the Section 3.7, 3.8, and 3.9 of the Report. | Prior to completion of final WVS PEIS, and during subsequent site-specific NEPA evaluations |
| Executive Order 13287, "Preserve America" | Enhances practices that protect the cultural heritage of the U.S. | | USACE recognizes the importance of historic properties within the WVS PEIS study area and will work with State and National agencies to determine if any Proposed Actions would affect those properties.". | Prior to completion of final WVS PEIS, and during subsequent site-specific NEPA evaluations |

# CHAPTER 8 - GLOSSARY

## A

**Access point:** A place where people access a site for recreation. An access point might include a boat launch, a campground, a parking area, etc. A recreation area may contain one or more access points.

**Acre-foot:** The volume of water that will cover an area of 1 acre to a depth of 1 foot. Equals 325,851 gallons.

**Ambient air:** Ambient air is the air in the atmosphere surrounding a particular place, such as a powerplant.

**Anadromous fish:** Fish, such as salmon or steelhead trout, that hatch in fresh water, migrate to and mature in the ocean, and return to fresh water as adults to spawn.

**Artifact:** An object of any type made by human hands. Tools, weapons, pottery, and sculptured and engraved objects are artifacts.

**Augment:** Increase; in this application, to increase river flows above rates that would occur under normal operation by releasing more water from storage reservoirs.

**Average megawatt (aMW):** A unit of energy that represents 1 megawatt of electric power capacity continuously over a year. Because there are 8,760 hours in a year, ne aMW is equal to 8,760 megawatts per hour.

## B

**Base flow:** The portion of streamflow that is sustained between precipitation events, fed to streams by delayed pathways.

**Bypass system:** Structure in a dam that provides a route for fish to move through or around the dam without going through the turbines.

## C

**Capacity:** The maximum load that a generator, piece of equipment, substation, transmission line, or system can carry under existing service conditions. Baseload capacity is the power output that can be continuously produced to run at least 70 percent of the time. Firm capacity is the capacity whose availability is ensured to the purchaser.

**Conservation Plan:** A plan prepared annually which provides flow requirements based on the basin water supply for that year.

**Conservation Pool:** the set amount of water in a reservoir dedicated for storage needs for municipal, domestic, agricultural (irrigation), industrial, fish and wildlife, water quality, and/or recreational use.

**Conservation Season**: March through October, including the filling season (spring) and the release season (summer), when the WVS reservoirs impound water for release later in the year.

**Critical water year (or "critical water conditions"):** Represent the historic water year (in this case, 1937) when the capability of the hydropower system produces the least.

**Cubic feet per second (cfs):** A unit of measurement pertaining to flow or discharge of water. One cfs is equal to 449 gallons (1.7 cubic meters) per minute.

**Cultural resources:** The non-renewable evidence of human occupation or activity as seen in any district, site, building, structure, artifact, ruin, object, work of art, architecture, or natural feature that was part of human history at the national, state, or local level.

**D**

**Demand:** For electrical energy, the rate at which it is used, whether at a given instant or averaged over any designated period of time.

**Discharge:** Volume of water flowing past a point at a given time, usually expressed in cubic feet per second.

**Dissolved gas concentrations:** The amount of elements or compounds normally occurring as gases, such as nitrogen and oxygen, which are held in solution in water, expressed in units such as milligrams of the gas per liter of liquid.

**Draft:** Release of water from a storage reservoir.

**Draft rate:** The rate at which water, released from storage behind a dam, reduces the elevation of the reservoir.

**Drawdown:** The distance that the water surface of a reservoir is lowered from a given elevation as water is released from the reservoir. Also refers to the act of lowering reservoir levels.

**E**

**Economic value:** The difference between the maximum amount a recreationist would be willing to pay to participate in a recreational activity and the actual cost of participating in that activity. This is referred to by economists as consumer surplus or net economic value.

**Electricity:** Electric current used or regarded as a source of power.

**Endangered:** A plant or animal species or sub-species which is in danger of extinction throughout all or a significant portion of its range because its habitat is threatened with destruction, drastic modification, or severe curtailment, or because of overexploitation, disease, predation, or other factors; federally endangered species are officially designated by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service and published in the *Federal Register.*

**Endemic:** Native or limited to a certain region.

**Energy:** As commonly used in the electric utility industry, electric energy means kilowatt-hours, or joules (the level of power delivered multiplied by the amount of time that the level of power is delivered). Used interchangeably with, although technically not a synonym of, power.

**Entrainment:** The drawing of fish and other aquatic organisms into tubes or tunnels carrying water for cooling purposes into thermal plants, or for power generating purposes into hydroelectric plants. Entrainment increases mortality rates for those organisms.

**F**

**Firm energy:** Energy considered ensurable to the customer to meet all agreed-upon portions of the customer's load requirements over a defined period. As defined in Bonneville Power Administration's system, electric energy produced under critical water conditions.

**Fishery:** Generally defined as a group of individuals or vessels that catch finfish or harvest shellfish, with specific commonalities in activity, including the fish species or stock targeted, the gear used, the location of activity, and the season of activity.

**Fish hatchery:** A facility in which fish eggs are incubated and hatched and juvenile fish are reared for release to rivers or lakes.

**Fish ladders:** A series of ascending pools constructed to enable salmon or other fish to swim upstream around or over a dam.

**Fish passage facilities:** Features of a dam that enable fish to move around, through, or over without harm. Generally, an upstream fish ladder or a downstream bypass system.

**Flow:** The volume of water passing a given point per unit of time.

**Forebay:** The portion of the reservoir at a hydroelectric plant which is immediately upstream of the generating station.

**Freshet:** A rapid temporary rise in streamflow caused by heavy rains or rapid snowmelt.

**Full pool:** The maximum level of a reservoir under its established normal operating range.

**G**

**Generation:** The act of producing electricity from other forms of energy (e.g., chemical, kinetic, gravitational, potential) or the amount of electrical energy produced.

**H**

**Hydraulic head:** The vertical distance between the surface of the reservoir and the surface of the river immediately downstream from the turbines and dam.

**Hydroelectric:** The production of electric power through use of the gravitational force of falling water.

**Hydrology:** The science that studies the continuous cycle of evapotranspiration, precipitation, and runoff, driven by solar energy.

**Hydrosystem:** An at least partially regulated freshwater system that is made up of water and the associated aquatic environments within a delimited geographical entity that fish use to complete their life cycle.

**I**

**Inflow:** Water that flows into a reservoir or forebay during a specified period.

**Intake:** The entrance to a conduit through a dam or water facility.

**Intertie:** A transmission line or system of transmission lines permitting a flow of energy between major power systems. The Bonneville Power Administration transmission grid has interties to British Columbia, Canada; California; and eastern Montana.

**J**

**Jobs:** Combined full- and part-time jobs on an annualized basis.

**Juvenile:** The early freshwater stage in the life cycle of anadromous fish up to and including when they migrate downstream to the ocean as a smolt.

**K**

**kcfs:** Thousand cubic feet per second; a measurement of water flow equivalent to 1,000 cubic feet of water passing a given point in one second.

**L**

**Labor income**: includes employee compensation and proprietary income. Employee compensation consists of wage and salary payments as well as benefits (e.g., health and retirement benefits) and employer paid payroll taxes (e.g., employer social security contributions and unemployment taxes). Proprietary income consists of payments received by self-employed individuals (such as doctors and lawyers) and unincorporated business owners.

**Levee:** An embankment constructed to prevent a river from overflowing.

**Littoral zone:** The shallower waters near the shore of a reservoir or lake.

**Load:** The amount of electric power or energy delivered or required at any specified point or points on a system. Load originates primarily at the energy-consuming equipment and electrical appliances of customers.

**Load shaping:** The adjustment of storage releases so that generation and load are continuously in balance.

**Low pool:** At or near the minimum level of a reservoir under its established normal operating range.

**M**

**Macrophytes:** Aquatic plants that are macroscopic, or large enough to be seen with the naked eye.

**Mainstem:** The principal river in a basin, as opposed to the tributary streams and smaller rivers that feed into it.

**Maintenance:** Work to restore equipment, assets, facilities or components to design conditions or to conditions that have been determined to be sufficient to meet a prescribed level of performance (vice "activities directed toward keeping assets in an acceptable condition"); replacement of parts, systems, or components; preventive maintenance and inspection/monitoring of facilities or equipment and other activities needed to preserve or maintain the asset. Maintenance and repairs, as distinguished from capital improvements, exclude activities directed towards expanding the capacity of an asset or otherwise upgrading it to serve needs different from, or significantly greater than, its current use.

**Major Maintenance:** A non-repetitive item of work or aggregate items of related work for which the total estimated cost exceeds the limit set forth by Engineering Circular 11-2-222, and which does not qualify as major rehabilitation.

**Major Rehabilitation.** Rehabilitation projects are projects to restore or ensure continuation of project functions or outputs.

**Maximum Pool:** the maximum level to which the reservoir surface is allowed to rise during normal operating conditions.

**Megawatt (MW) and kilowatt (kW):** A watt is a unit of power, equal to one joule of energy per second. One kilowatt equals one thousand watts. One megawatt represents 1,000 kilowatts or 1 million watts. MW is a standard metric describing electric power generating capacity.

**Megawatt hours (MWh) and kilowatt hours (kWh):** MWh and kWh are energy measurements denoting electricity production or consumption. One MWh equals 1,000 kWh. In the electricity context, power (MW) is the rate of producing, transferring, or using energy, and energy (MWh) is power used over a period of time.

**Model:** A mathematical function with parameters that can be adjusted so that the function closely describes a set of empirical data. A "mathematical" or "mechanistic" model is usually based on biological or physical mechanisms and has model parameters that have real-world interpretations. In contrast, "statistical" or "empirical" models involve curve-fitting to data where the math function used is selected for its numerical properties. Extrapolation from mechanistic models (e.g., pharmacokinetic equations) usually carries higher confidence than extrapolation using empirical models (e.g., logic).

**Minimum operating pool (MOP):** The minimum elevation of the established normal operating range of a reservoir.

**N**

**Nature-based structures:** Landscape features that are used to provide engineering functions relevant to flood risk management, while producing additional economic, environmental, and/or social benefits.

**O**

**Operating limits:** Limits or requirements that must be factored into the planning process for operating reservoirs and generating projects. (Also see operating requirements, below.)

**Operating requirements:** Guidelines and limits that must be followed in the operation of a reservoir or generating project. These requirements may originate in authorizing legislation, physical plant limitations, or other sources. Non-power operating requirements pertain to navigation, flood control, recreation, irrigation, and other non-power uses of a river.

**Outages:** Periods, both planned and unexpected, during which the transmission of power stops or a particular power-producing facility ceases to provide generation.

**Outflow:** The volume of water per unit of time discharged at a project.

**P**

**Particulates:** Substances that consist of minute separate particles, such as dust or soot.

**Peak load:** The maximum load in a stated period of time. It may be the maximum load at a given instant in the stated period or the maximum average load within a designated interval of the stated period of time. Peak can also be used to refer to the maximum capacity or energy.

**Peaking or peaking capacity:** The generating capacity available to assist in meeting that portion of the load that is above baseload. Alternatively, the maximum output of a generating plant or plants during a specified peak-load period.

**Phytoplankton:** The plant portion of floating or weakly swimming organisms, often microscopic in size, in a body of water.

**Pool:** Reservoir; a body of water impounded by a dam.

**Power:** The rate of energy production or transfer. Power is expressed in watts (1 watt = 1 joule per second) and used interchangeably with energy, although it is technically not a synonym of energy. Power delivered to a load is also called demand.

**Power Pool:** The reservoir capacity between the inactive and conservation pools and is only designated for reservoirs that have power production capabilities.

**R**

**Record of Decision (ROD)**: A document notifying the public of a decision made by a Federal agency, together with the reasons for making that decision. Records of Decision are published in the *Federal Register.*

**Recreation area**: A reservoir, river reach between reservoirs, or the Pacific Ocean off the coast of Oregon and Washington, used for recreation. A recreation area may have one or more access points.

**Recruits:** The number of offspring that successfully survive and return to breed.

**Redds:** Salmon spawning nests in gravel.

**Refill:** Refers to the annual process of filling a reservoir in the spring to the maximum conservation season elevation, at which point the reservoir is considered “full”.

**Regional economic contributions**: These reflect economic activity within a specific geographic region supported by expenditures for a particular economic sector (e.g., recreational visitation). Contributions are often measured in terms of sales (spending), jobs, income, and value added, though other measures may be used.

**Regulating Outlet (RO):** Lower elevation dam outlet to allow flow through the dam while not using any hydroelectric turbine.

**Reliability:** For a power system, a measure of the degree of certainty that the system will continue to meet load for a specified period of time.

**Replacement potential:** Whether each generation of a salmon species produce enough juveniles to at least replace itself.

**Reregulating dam**: a project whose primary purpose is to enable higher variation in flow from an upstream dam, typically in a sub-daily timeframe and has minimal usable flood or conservation season storage.

**Reservoir elevations:** The levels of the water stored behind dams.

**Reservoir storage:** The volume of water in a reservoir at a given time.

**Resident fish:** Fish species that reside in fresh water throughout their lives.

**Residualize:** When migrating juvenile salmonid smolts lose their urge to migrate, physiologically revert to their freshwater life form, and remain in fresh water rather than migrate to sea.

**Riprap:** Broken rock, cobbles, or boulders placed on the bank of a stream or river for protection against the erosive action of water.

**Rule curves:** Seasonal reservoir elevation targets or restrictions, represented graphically as curves, that guide reservoir operations.

**S**

**Salmonids:** Fish of the taxonomic family Salmonidae, such as salmon, trout (including steelhead), char, and whitefish. Pacific salmonids in the genus *Oncorhynchus* include Chinook (king), coho (silver), sockeye (red), chum (dog), and pink (humback).

**Scoping:** The process of defining the scope of a study, primarily with respect to the issues, geographic area, and alternatives to be considered. The term is typically used in association with soliciting input from the public (e.g., non-governmental organizations, individuals, other government agencies, stakeholders) to help define the scope of environmental documents prepared under the National Environmental Policy Act.

**Sedimentation:** The settling of material (such as dust, silt, or other particles) into water and eventual deposition on the bottoms of streams, rivers, lakes, and reservoirs.

**Simulation:** The representation of an actual system by analogous characteristics of a device that is easier to construct, modify, or understand, or by mathematical equations (i.e., a model).

**Smolt:** A juvenile salmon or steelhead migrating downstream to the ocean and undergoing physiological changes to adapt its body from a freshwater to a saltwater environment.

**Spawning:** The release and fertilization of eggs by fish.

**Spending**: Equivalent to the sales by firms in the region. This can be expressed in terms of (1) recreation expenditures, and/or (2) final demand, which is the total sales by firms in the region from all buyers, including recreationists, as well as businesses and households in subsequent rounds of spending.

**Spill:** Water passed over a spillway or through a regulating outlet without going through turbines to produce electricity. Spill can be forced, when there is no storage capability and flows exceed turbine capacity, or planned, for example, when water is spilled to enhance juvenile fish passage.

**Spillway:** Overflow structure of a dam

**Stochastic:** Involving chance or probability.

**Storage reservoirs:** Reservoirs that have storage for regulating high inflows to reduce downstream flooding or storing spring runoff for use later in the dry season.

**Streamflow:** The rate at which water passes a given point in a stream, usually expressed in cubic feet per second.

**Subyearlings:** Juvenile fish less than 1 year old.

**Surplus energy:** Energy generated that is beyond the immediate needs of the producing system. This energy may be sold on an interruptible basis or as firm power.

**System flood control:** Flood protection provided along the Willamette River and its tributaries downstream of the Willamette Valley System of reservoirs.

**T**

**Tailrace:** The canal or channel that carries water away from a dam.

**Tailwater:** The water surface immediately downstream from a dam or hydroelectric powerplant.

**Thermocline:**

**Threatened:** Legal status afforded to plant or animal species that are likely to become endangered within the foreseeable future throughout all or a significant portion of their range, as determined by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service.

**Transmission path:** A path refers to a route over which the power flows from one point to another (i.e., the direction power flows across a transmission line).

**Tules:** The name commonly applied to fall chinook salmon originating on the lower Columbia River.

**Turbidity:** A measure of the optical clarity of water, which depends on the light scattering and absorption characteristics of suspended and dissolved material in the water.

**Turbine:** Machinery that converts kinetic energy of a moving fluid, such as falling water, to mechanical or electrical power.

**V**

**Velocity:** Speed; the rate of linear motion in a given direction.

**Viable Salmonid Population (VSP):** A salmonid population that meets threshold criteria for spatial structure, diversity, productivity, abundance, and risk of extinction as determined by the NOAA Viable Salmonid Population (VSP) framework (McElhaney et al. 2000). In general, higher VSP scores indicate greater viability. VSP scores are calculated from the output of salmonid population models. These models tend to cover all or most of the salmonid life cycle. Most information comes from the hydrosystem because the ocean phase of the life cycle is less understood.

**W**

**Water conditions:** The overall supply of water to operate the hydroelectric generating system at any given time, taking into account reservoir levels, snowpack, any needs to provide water or retain water to meet various operating constraints (such as the water budget, flood control, flow constraints, etc.), weather conditions, and other factors.

**Water Control Diagram:** A diagram used to illustrate reservoir elevation targets for the reservoirs, known as water-year-based rule curves.

**Water particle travel time:** The theoretical time that a water particle would take to travel through a given reservoir or river reach. It is calculated by dividing the flow (volume of water per unit time) by the cross-sectional area of the channel.

**Water retention time:** The length of time that a particle of water is resident in a lake or reservoir, based on rates of inflow, outflow, and circulation within the waterbody.

**Water rights:** Priority claims to water. In Western states, water rights are based on the principle “first in time, first in right,” meaning older claims take precedence over newer ones.

**Water year:** One hydrologic cycle corresponding to October 1 through September 30. The start of a water year is typically prior to the start of higher winter flows in the Willamette River Basin.

**Y**

**Yearlings:** One-year-old juvenile salmon and steelhead.

**Z**

**Zooplankton:** Aquatic animals that cannot actively swim against the current and cannot make their own food by photosynthesis.

# CHAPTER 9 - LIST OF PREPARERS

**Table 8-1. List of Preparers**

| Name | Title | Years of Experience | Degree/Experience/Expertise | Agency | EIS Areas Authored/Contributed |
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| Holly H. Bellringer | Biologist | 15 | M.S. Environmental Science<br>B.S. Marine Biology<br>Water Quality | USACE | Author: Water Quality, including Appendix D |
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| Elisabeth K. Bowers | Environmental Resource Specialist, Professional Wetland Scientist | 16 | B.S. Environmental Science and Hydrogeology<br>Wetland Science and Biology | USACE | Author: Vegetation, Wetlands, and Wildlife, Birds, and Terrestrial Habitat |
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| Ryan Cahill | Hydraulic Engineer | 12 | M.S. Civil and Environmental Engineering<br>B.S. Civil Engineering<br>Hydraulics and Hydrology | USACE | Peer Reviewer |

| Name | Title | Years of Experience | Degree/Experience/Expertise | Agency | EIS Areas Authored/Contributed |
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| Garrett Dorsey | Chief, Environmental Planning Section | 16 | B.S. Wildlife Science<br>Environmental Compliance and Biology | USACE | Co-Author: Vegetation, Wetlands, and Wildlife, Birds, and Terrestrial Habitat |
| Keith Duffy | H&H Engineer | 24 | B.S. Civil Engineering<br>Hydrology and River Hydraulics /Climate Change | USACE | Author: Climate Change Appendices, Assessment and Supplemental Climate Change Information |
| Brad Eppard | Fish Passage Section Chief | 28 | B.S. Fish and Wildlife Management<br>Fish passage behavior and survival | USACE | Peer Reviewer |
| Tim Ernster | Operations & Maintenance Manager | x | Detroit and Big Cliff dams | USACE | Peer Reviewer |
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| Name | Title | Years of Experience | Degree/Experience/Expertise | Agency | EIS Areas Authored/Contributed |
|---|---|---|---|---|---|
| | | | Environmental Compliance, and Plan Formulation | | Evaluation), and 5 (Preferred Alternative Selection and Implementation); Appendix A (Alternatives Development); and Appendix P (Public Scoping Report) Co-Author: Chapter 3.1 Introduction and Background for Affected Environment and Environmental Consequences and Chapter 7 Compliance With Environmental Laws, Regulations, and Executive And Secretarial Orders |
| Dennis L. Johnson | Economist | 9 | BS Business Administration - Economics minor<br>Flood Risk Management, Recreation Economics | USACE | Co-Author: Socioeconomics, Chapter 3.1 (Methods, Environmental Consequences), Appendix M (Cost), and Appendix K (Recreation) |
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| Oliver King | | | | USACE | Peer Reviewer |
| Rachel D. Laird | Fish Biologist | 15 | M.S. Wildlife and Fisheries Sciences<br>B.S. Marine Biology<br>Population Dynamics Modeling | USACE | Author: Fish and Aquatic Habitat, including Appendix E |
| Chanda Littles | Environmental Resource Specialist | 20 | PhD Interdisciplinary Ecology; Coastal Ecology | USACE | Peer Reviewer |
| Christopher A. McCann | Economist | 11 | B.A. Economics<br>Water Resource Economist | USACE | Peer Reviewer |
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| Name | Title | Years of Experience | Degree/Experience/Expertise | Agency | EIS Areas Authored/Contributed |
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| Omar Ortiz | Environmental Resource Specialist | 10 | M.S. Community and Regional Planning<br>Civil Works NEPA Process, Environmental Compliance | USACE | Author: Chapter 3.1 Introduction and Background for Affected Environment and Environmental Consequences and Chapter 7 Compliance with Environmental Laws, Regulations, and Executive and Secretarial Orders<br>Reviewer: Chapter 3 and 4 |
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| Michael V. Snyder | Environmental Resources Specialist | 23 | M.S. Biological Sciences<br>NEPA, Environmental Compliance, and Natural Resources Planning | USACE | Author: Adaptive Management Plan |
| Kathryn L. Tackley | Physical Scientist | 26 | B.S. Physical Geography & Geology<br>Water Quality | USACE | Author: Implementation Plan<br>Peer Reviewer: Chapter 3.2 and 3.3 |
| Greg Taylor | Fish Biologist | 25 | B.S. Biology | USACE | Peer Reviewer |
| Kathryn L. Warner | Environmental Engineer | 24 | M.S. Water Resources Management<br>M.S. Civil Environmental Engineering<br>B.A. Chemistry | USACE | Author: Water Supply, including Appendix J<br>Co-Author: Chapters 1 (Introduction) and 2 (Alternatives Development and Evaluation) |
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| **Bonneville Power Administration** | | | | | |
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| Anders L. Johnson | Electrical Engineer | 19 | M.S. Electrical Engineering<br>B.S. Electrical Engineering<br>Transmission Planning | BPA | Co-Author and Reviewer: Power and Transmission |
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| Leon Kolankiewicz | Senior Environmental Manager | 38 | M.S. Environmental Planning<br>B.S. Forestry and Wildlife Management | Solv | NEPA Technical Lead; Author: Transportation/Navigation; Cumulative Effects Scenario; Chapters 1 and 2; Executive Summary |
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| Name | Title | Years of Experience | Degree/Experience/Expertise | Agency | EIS Areas Authored/Contributed |
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| Joseph DeMarco | Environmental Scientist | 6 | M.P.A. Environmental Science and Policy<br>B.S. Chemistry (Biochemistry focus) | Solv | Author: Air Quality, Climate Change |

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